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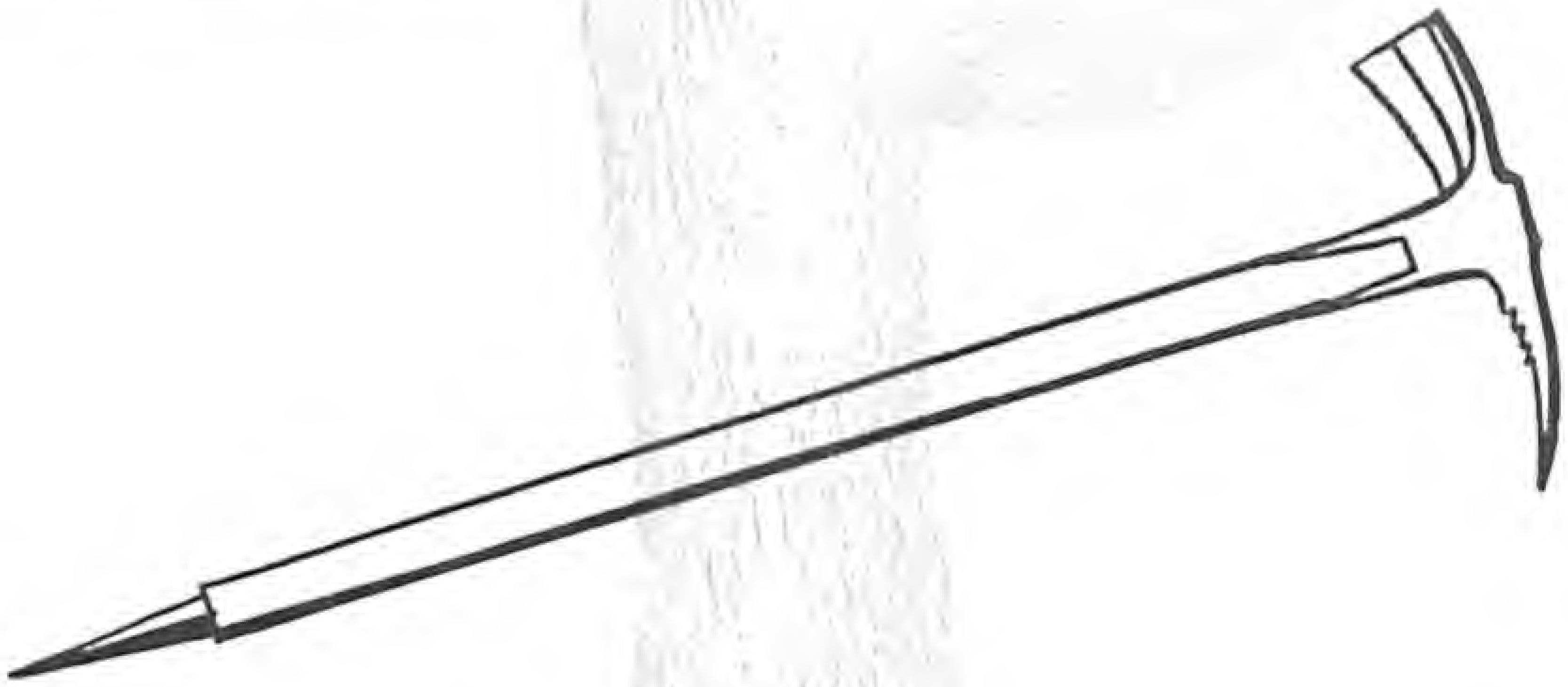

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SEARCH AND DISCOVERY

An Invitation

Edited by
PHILIP MOOSE

INDIAN BRANCH

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PREFACE

EDUCATION implies activity: one learns by doing, even though it is only to try a different way next time. It is this active, experimental approach to life that I have tried to encourage students to adopt in this little book, in which the two themes are the achievements of science and the delights of strenuous exercise. A rather novel feature is that this book is not a compilation, but consists of chapters specially written for students in India and Pakistan by authors qualified, in all cases but one, by personal experience on the spot.

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Dr Rollier with Madhuri Desai, when she visited Leysin on 29 October 1948. The photograph was taken in the clinic of Dr Rollier when he was on his rounds, seeing the patients. Dr Rollier is 75 years old, but looks 50. He still works as much as any of his assistants, much younger men.

NATURE'S WONDERFUL FREE GIFT

by

MADHURI DESAI

Author of 'To the Builders of Tomorrow': now living in Switzerland

I

IT WAS A WET DAY. The rain had ceased to pour but the atmosphere was loaded with water. By the road-side, a man was frantically trying to light a fire. He struck many a match but none would light. In disgust he threw away the match-box.

Forlorn, he sat wondering what was wrong. Yes, the matches were damp. Water had got into the box. To restore the power of the match to glow again he must remove the water.

It is like that with human beings. When damp and darkness surround us, disease microbes, especially the microbes of tuberculosis, attack us. When that happens, the sparkle from our lives disappears. We become useless like the sticks of flimsy wood the man discarded.

Our India is a wonderful land of perpetual sunshine. More fortunate than the people of Europe, we can avail ourselves of nature's free gift—the Sun, and keep our bodies healthy. But

we have barred our doors to the sun by unhygienic buildings, slums and overcrowding. The result is tuberculosis on a major scale.

I will tell you the story of Dr Rollier, the Swiss lover of the sun, and how he evolved a new method of cure for tuberculosis.

August Rollier was born in the beautiful mountainous land of Switzerland. He lived in Neuchâtel and delighted in the quiet beauty of the lake, on whose banks he often sat and dreamed. His father was a teacher who loved books and dark corners of libraries. Such was the father of the pale-faced and weak August. The sons of the farmers who went to school with August were much stronger than him. In a free fight August was always the loser. He decided that he must be a strong man—a Red Indian! He had heard that the skin of the Indian was brown. So he began to roast his body in the sun day after day in order to get the right colour.

That was his first worship at the altar of the sun. The sands of time were running out for the nineteenth century. Not more than a dozen years were left before the dawn of the twentieth century.

August had a pet dog. The spaniel developed a tumour on its back. Here was an opportunity for surgery. August took his knife and lanced the tumour. He neatly bandaged the wound and

calmly waited for it to heal. But the dog was wiser than its self-appointed doctor. As soon as its master was absent, the dog with great difficulty pulled off the dressing. Then it went and exposed its wound to the sun. It refused the man-made dressings. It preferred the direct rays of the sun. To the surprise of August the wound healed. He made a mental note of the incident. He was not ashamed to learn from the instinct of his dumb friend.

II

Rollier grew up to manhood and learnt to wield the knife of the surgeon skilfully. His *guru* was Kocher, a man renowned for his feats on the operating-table.

One day Rollier was surprised to meet one of his old school-mates. He was a patient of Kocher. He had injured his hip in a gymnasium and had developed T.B. of the joint. Kocher operated on him. Soon he was discharged as cured, with the slight defect of one leg being a little shorter than the other.

After some time the friend reappeared, complaining of pain in the knee-joint. In quick succession the surgeon had to cut away not only the foot, but also a finger and a shoulder-joint. The disease had advanced and affected most of the body. After each operation Kocher and Rollier

were convinced that all the T.B. microbes had been destroyed. But they were wrong. Rollier's friend realized what awaited him. His patience was already exhausted. In a mood of depression, he put an end to his painful life by committing suicide.

Rollier was deeply moved by this tragedy. He realized that the surgeon's skilled knife was powerless against T.B. of the bones and joints. Was the struggle against this mortal foe of mankind hopeless? Rollier was not to be daunted. He had faith. He was sure that a solution to this problem must exist, only he did not yet know what it was. In earnest, he began his search, and carefully observed every phenomenon he came across.

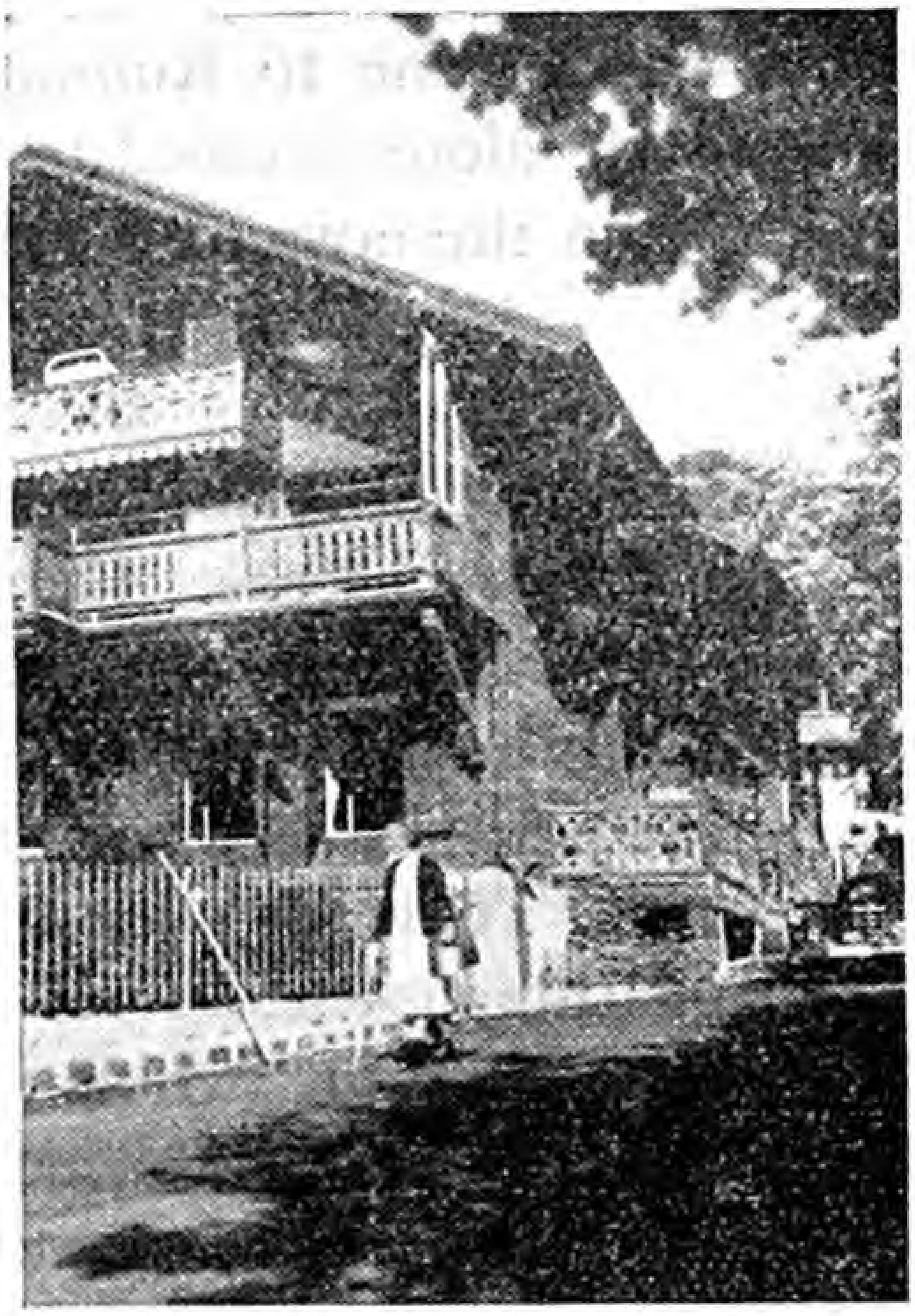
Rollier fell desperately in love with a girl. He was devoted to her and pledged her his eternal companionship. His affection was soon put to the test. The young girl developed T.B. of the lungs. She was sent away to Leysin, a mountain resort for rest and fresh-air cure.

Rollier was in a dilemma. Should he abandon his promising career as assistant of Kocher and follow his lady-love? He did not waver. He bid goodbye to his *guru*.

He went and settled in Leysin, and started practising as a surgeon there.

In Leysin Rollier heard the story of a strange custom among mountain people. They bathed their meat in the sun and thus preserved it against vermin. He heard their comment: 'Where the sun is, the doctor isn't.'

Rollier learnt in course of time that there was a doctor on the neighbouring hill, who healed wounds by exposing them to the sun. He saw his sweetheart also make rapid progress under the rays of the sun.



The first chalet where Dr Rollier came to stay with his wife in Leysin. Now it is used as a children's clinic.

This convinced Rollier of the power of the sun in effecting a cure for tuberculosis. He began to expose his patients to the sun, and saw them recover. His fame spread. People began to arrive from far-off lands to be healed by this doctor who no longer believed in the surgeon's knife. Crippled humanity, old and young, mounted the

steep road to Leysin. Shrivelled, dwarfed, deformed victims of T.B., with flushed cheeks, and premature death staring them in the face, pronounced as 'hopeless cases' by different physicians, came to Rollier. He was their last hope. He alone seemed to know the way to save them from the jaws of death.

III

Rollier developed his own technique of cautious handling of each case. He used no machines, he discarded his medicine bottles. He made his sanatorium a temple of the sun in which all were surrendered to the strong rays of the sun day after day. Their skin became brown like that of the Red Indians—Rollier's childhood heroes.

Rollier prepared a whole ritual for his patients. A newcomer was not allowed into full sunlight all at once. At first, the patient was lodged in a room whose windows and doors were never closed. The next step was to be brought on the balcony which was well shaded and where sunlight was indirect. Bandages and plaster-casts were increasingly removed and fresh air allowed to begin the healing process. All the time Rollier was near his patient, most times unseen, watching each development with the intensity of a mother for her ailing child. After a little while Rollier ordered the feet—and

only the feet—to be exposed to the direct rays of the sun. But that for only five minutes, three times a day. Another day, the exposure for the feet was increased to ten minutes. The legs upto the knees were now exposed to the sun for five minutes. And so on progressively, till the patient lay naked and unashamed under the sun.

Rollier took great care to avoid sun-burns and blisters. He was always ready to retrace his steps if a stone wall faced him in his climb up the uncharted hill of sun-healing.

All the time that the browning of the skin was taking place, wounds were healing, pains disappearing and new strength returning. Lost appetites reappeared and spontaneous joy and happiness chased away depression.

Evidently the sun-rays were penetrating deeper than the skin. A medical myth was being exploded.

In spite of Rollier's progressive outlook the world of medical men is a conservative world. In 1905 Rollier went to Paris and pleaded in a medical congress for recognition of his experiments with the sunlight. He was openly ridiculed. This did not deter Rollier. He piled one record on another, and patient after patient was cured and discharged.

He turned his attention to children and founded

chalets for them. Here children romped about bare-bodied in the sun all the day. He built sanatoria for the sick and preventoria for the weak and borderline cases. His chief, his only medicine, was sunshine, simple food and rest.

A corner of the sun-cure gallery

Rollier today has won his battle. He is no more in the position of the salt doll that goes to measure the depths of the sea. He is the acknowledged genius who has crowned tubercular humanity with health and happiness under clear, blue skies and smiling sun.

The camel has the uncanny habit of eating a thorny bush, even though the thorns draw blood from its jaws. Man is a superior being.

Man has learnt from Rollier the advantages of the sun. The T.B. thorns should no longer drain blood from the jaws of man.

The message of sun-bathing has gone farther and deeper. It is acknowledged by progressive medical men that the sun's rays have healing qualities not merely for the sick and the maimed. They play an essential role in keeping healthy human beings fit and active. Open your windows and let the sun come in. A regular sun-bath is a prescription for you as well as for me—for everybody.

The quality of sun-rays appears to differ according to altitude. Rays reflected back from the snow have greater efficacy than rays in a sea-level, tropical place. Dr Rollier has chosen the hill of Leysin for his healing institutions not without reason. But a good thing, though it can be better, is never bad. The simple teaching of Dr Rollier can be summed up in two sentences: Take the sun wherever you are, whenever you can. You will never be sorry for it.

Nature's wonderful free gift, the sun, is always there to cure you. You have to worship regularly at Rollier's shrine, abandon shade and step into its light. The path of 'kindly light' will lead you to happiness.

THE IMPORTANCE OF WATER IN INDIA AND PAKISTAN

by

JOHN AUDEN

Member of the Geological Survey of India, who has helped to choose the sites of several great irrigation works

I

FROM the earliest historical times water has been taken from rivers and wells for the purpose of growing crops. An inscription on the tomb of Queen Semiramis, who ruled in Assyria 4,000 years ago, proudly proclaims: *I constrained the mighty river to flow according to my will and led its waters to fertilize lands that before had been barren and without inhabitants.*

In India also wells, tanks, and canals have been in existence for thousands of years. Possibly the earliest canal developed by the British, the Western Yamuna Canal, was re-aligned from one which had been constructed by Firoze Shah in the fourteenth century. During the last hundred years of British rule a system of canals was put into operation to such an extent that India became the most irrigated country in the world. By 1945 as many as 30 million acres of land in the provinces of India and Pakistan were irrigated by

Government canals, and another 30 million acres by means of wells and tanks. The method employed was mainly the ancient one adopted by Queen Semiramis, and consisted in building a barrage, or low wall, across the rivers and leading the waters into canals on one or both sides of the

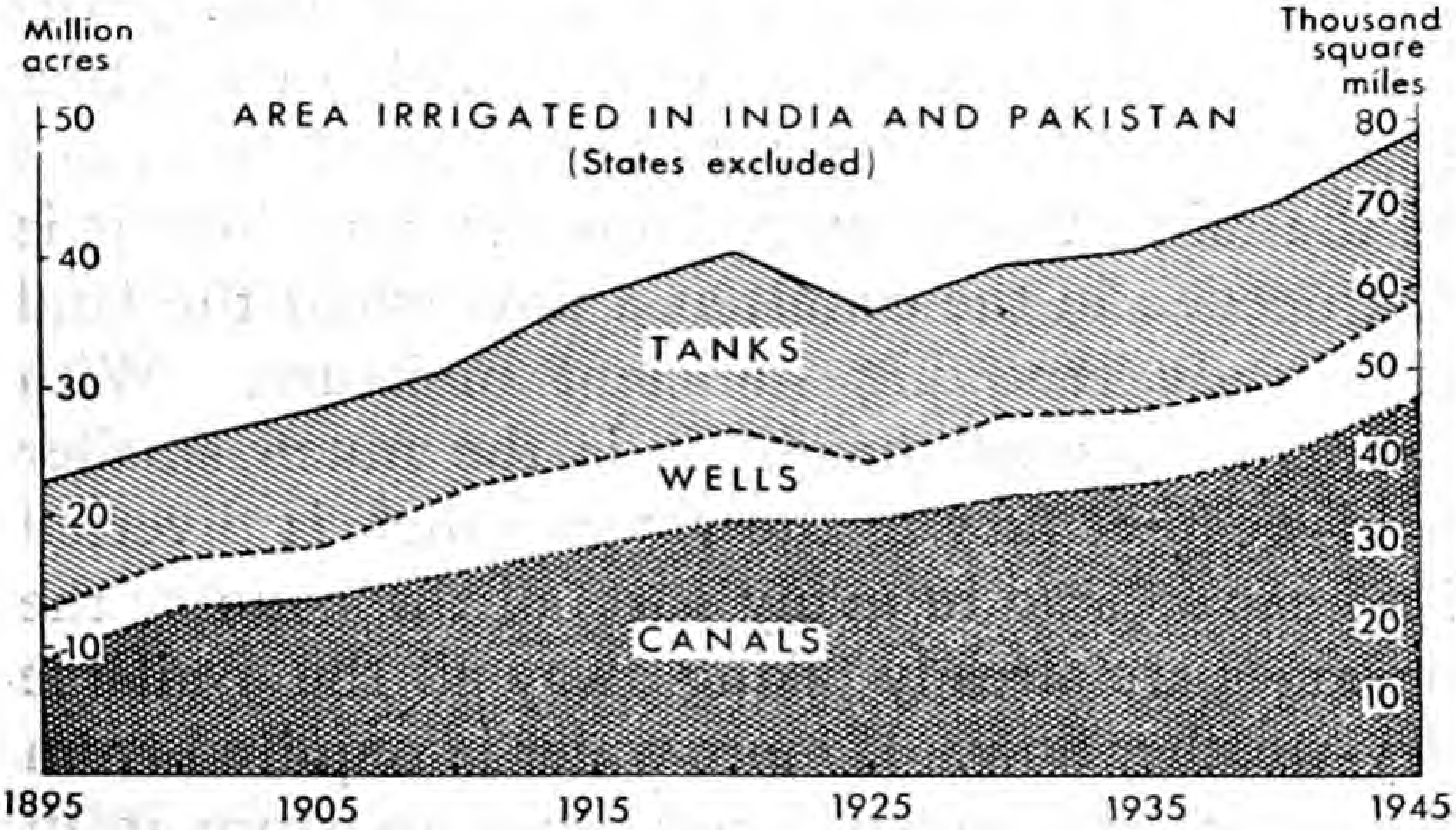


FIG. 1

While the area irrigated by tanks and wells has remained almost the same, there has been a great increase in the area irrigated by canals.

river. Figure 1 shows the area of land irrigated by wells, tanks and canals in the provinces of India and Pakistan between 1895 and 1945. In spite of the great development of irrigation, as much as 72 per cent of the total land under cultivation is still not irrigated, but depends

entirely on rainfall for the growth of crops. If the rainfall in any year is small, the crops may fail altogether.

The Indian climate is a monsoon climate and over most of the country 90 per cent of the rain comes in only four months of the year, while the remaining 10 per cent of the rain falls during the longer period of eight months. This means that in the monsoon the rivers are in flood and most of the rain runs to waste into the sea, since it is not needed in the canals at a time when the land is already receiving sufficient moisture. With barrages of small height it is the much smaller cold-weather flow of the rivers which is diverted into canals, and in many parts of the country the barrages are already taking away all the available dry-weather flow. If more water is required from the rivers, it becomes necessary to store it in mountain and hill valleys, as will be described shortly.

II

The population of India and Pakistan is increasing very rapidly. During the 50 years between 1891 and 1941 it has increased by 110 million inhabitants, from 279 million in 1891 to 389 million in 1941. If we take only the provinces of India and Pakistan, for which more complete data are available, the population has increased

in this period by 83 million, from 213 million to 296 million. Has the area of land which is cultivated increased in the same proportion? If you will look at the table below and at Figure 2,

PROVINCES OF INDIA AND PAKISTAN

States excluded

Date	Population (*millions*)	Total Cultivated Area (*million acres*)	Cultivated Area per Inhabitant (*fraction of acre*)	Total Irrigated Area (*million acres*)	Irrigated Area per Inhabitant (*fraction of acre*)
1891	213	188	0·88	26	0·12
1901	221	186	0·84	29	0·13
1911	232	210	0·91	40	0·17
1921	234	198	0·85	48	0·21
1931	257	211	0·82	48	0·19
1941	296	214	0·72	56	0·19
1891–1941	+83	+26	−0·16	+30	+0·07

you will see that, while in 1891 there was 0·88 acre of cultivated land for every individual inhabitant in the country, by 1941 this area had decreased to 0·72 acre. It is true that the amount of land actually irrigated by water from wells, tanks and canals has increased from 0·12 acre to 0·19 acre, yet this second figure is quite small

and represents a small field with square sides of 30 yards. The higher figure for 1921 is deceptive because, although the area of irrigated land was all the time increasing slightly, so many died from the influenza epidemic of 1918-19 that the population actually decreased. Pestilence and famine are natural and periodical checks on the growth of populations if they have a low standard of living and poor medical facilities.

Another point must be considered. The rainfall at a place varies in quantity from year to year. In Ajmer, for example, the average rainfall for the 52 years between 1891 and 1942 was 20 inches. But the average rainfall is a mathematical idea and it is very seldom in most areas that the rainfall in any particular year is the same as the average. In 1917 the rainfall at Ajmer was as much as 44 inches, or 24 inches above average. In 1891 and 1918 the rainfall was as low as 5 inches, or 15 inches below average. During the period of 52 years there were 7 years in which the rainfall was less than half the average, that is, less than 10 inches. This departure from average is very important in the case of crops which are not irrigated but depend entirely on rainfall for watering.

During years of excessive rainfall the crops may be drowned, as happened during the appalling

floods of the Ganga in 1948. While flying over the area of the Ganga above Patna and Banaras

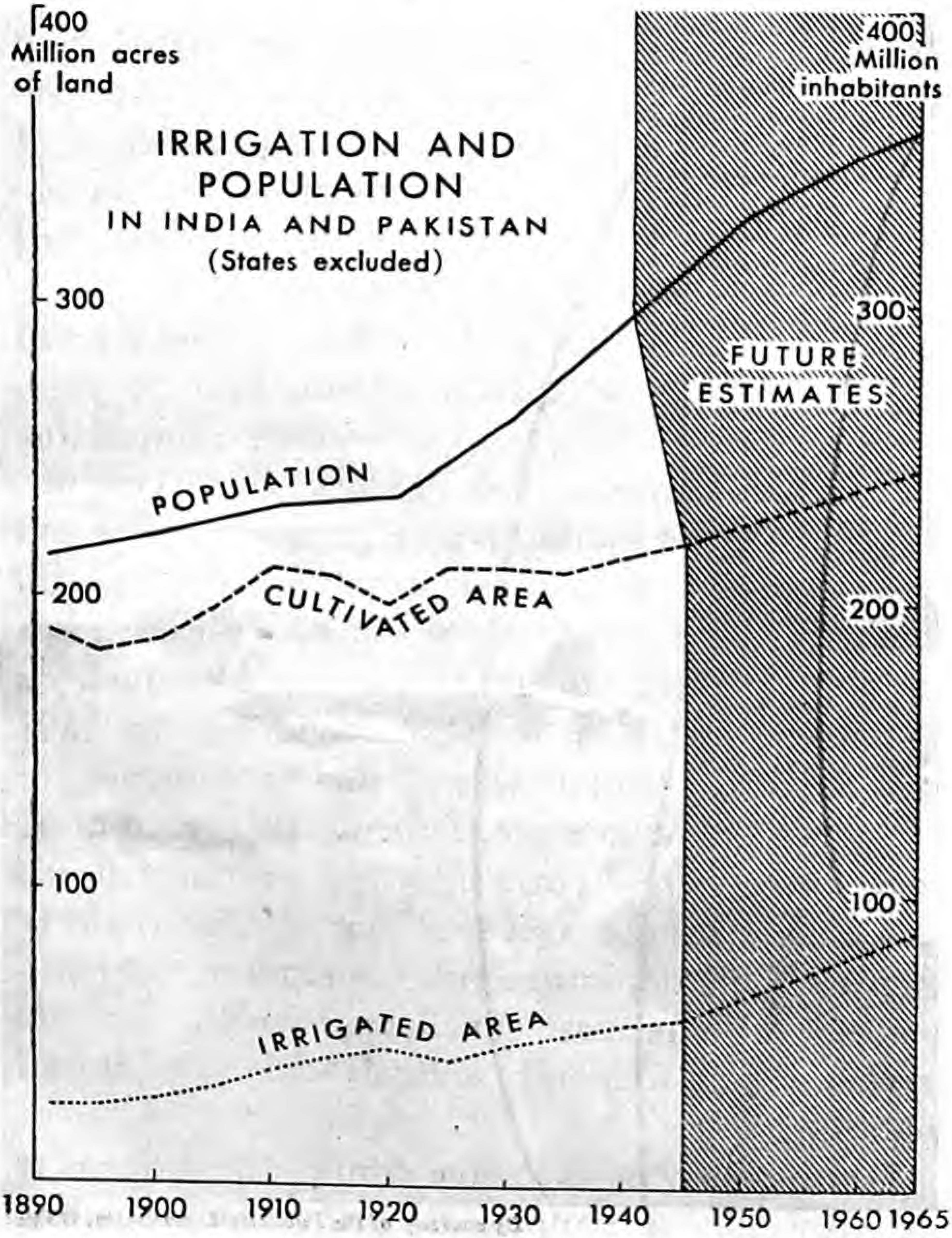


FIG. 2

one saw hundreds of square miles of land so covered with water that no field bunds or crops

By courtesy of the Publicity Department, Bengal

Flooded areas near Chittagong, in 1946

could be seen, and villages stood out of the water, some of them partly submerged, like islands in the sea. These floods were due to very heavy rainfall in the catchments of tributaries of the Ganga occurring during a period of a few days. In 1943 heavy rain fell in the Damodar basin and the floods not only ruined many crops, but they caused serious breaches in the main railway line of the E.I.R. between Calcutta and Burdwan. This was in war time, and the E.I.R. was a vital link between northern India and the fighting front in Assam and Burma. Months were spent in repairing the line, during which time all railway traffic had to be diverted through Midnapore. These are cases of the production of famine conditions, and interrupted communications, by the presence of too much water from uncontrolled rivers.

The more usual cause of famine is, however, abnormally low rainfall, which also results in the failure of crops for the people and fodder for cattle. During the Rajputana famine of 1939-40 the Government of India and the Jodhpur Government spent lakhs of rupees in feeding and giving work to villagers who had had to leave their homes because the wells had dried up and the crops had perished. Figures 3 and 4 show the frequencies of drought years and famines in India and Pakistan during recent historical times. The

suffering which resulted from these famines and the cost of providing relief have been very great.

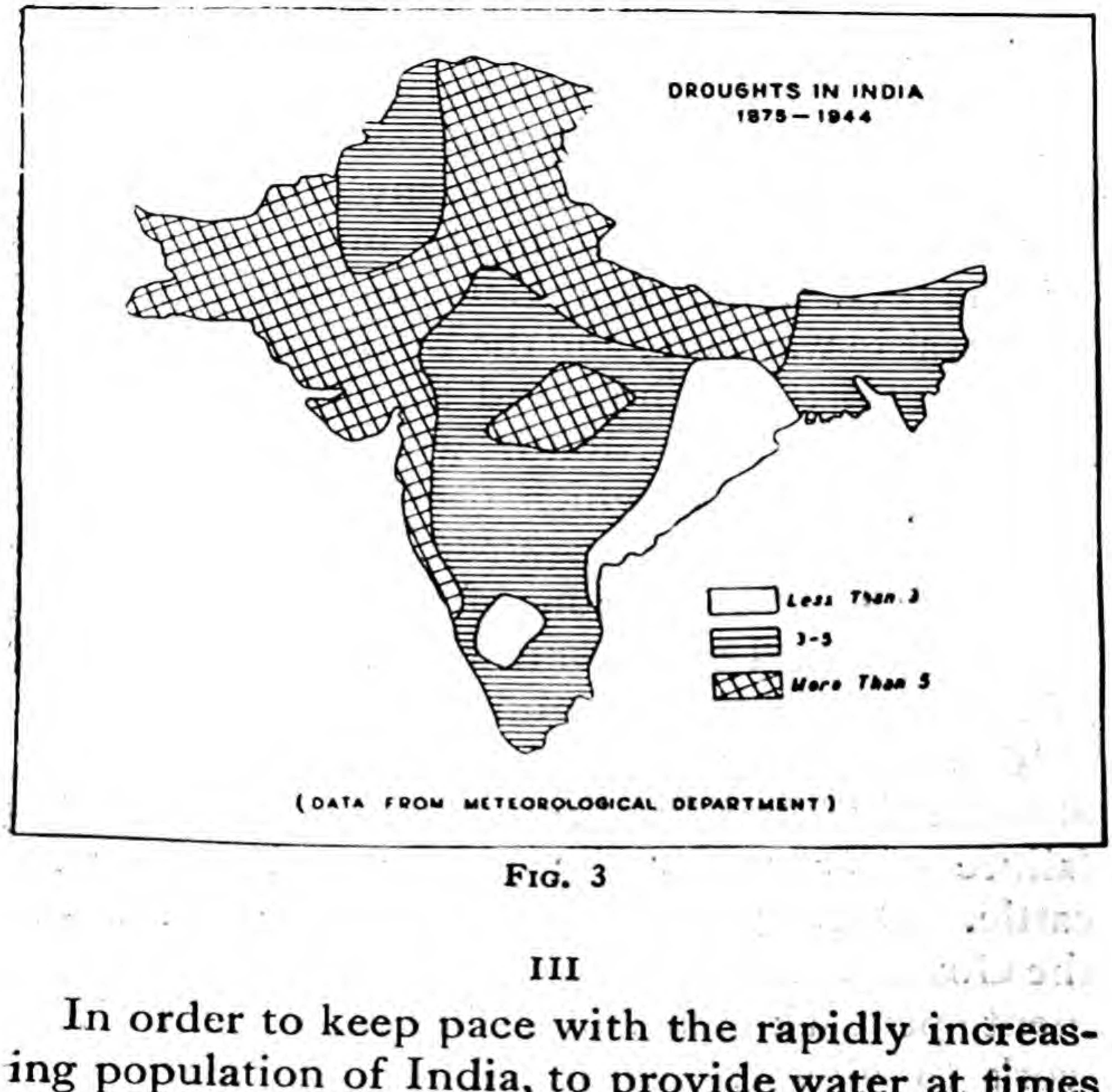


Fig. 3

III

In order to keep pace with the rapidly increasing population of India, to provide water at times when rainfall is low, and to prevent floods, it is necessary that something should be done to the great rivers of India. Some of the proposed projects are similar to those which already exist in

India, but others involve a type of engineering which is new to many parts of the country. The

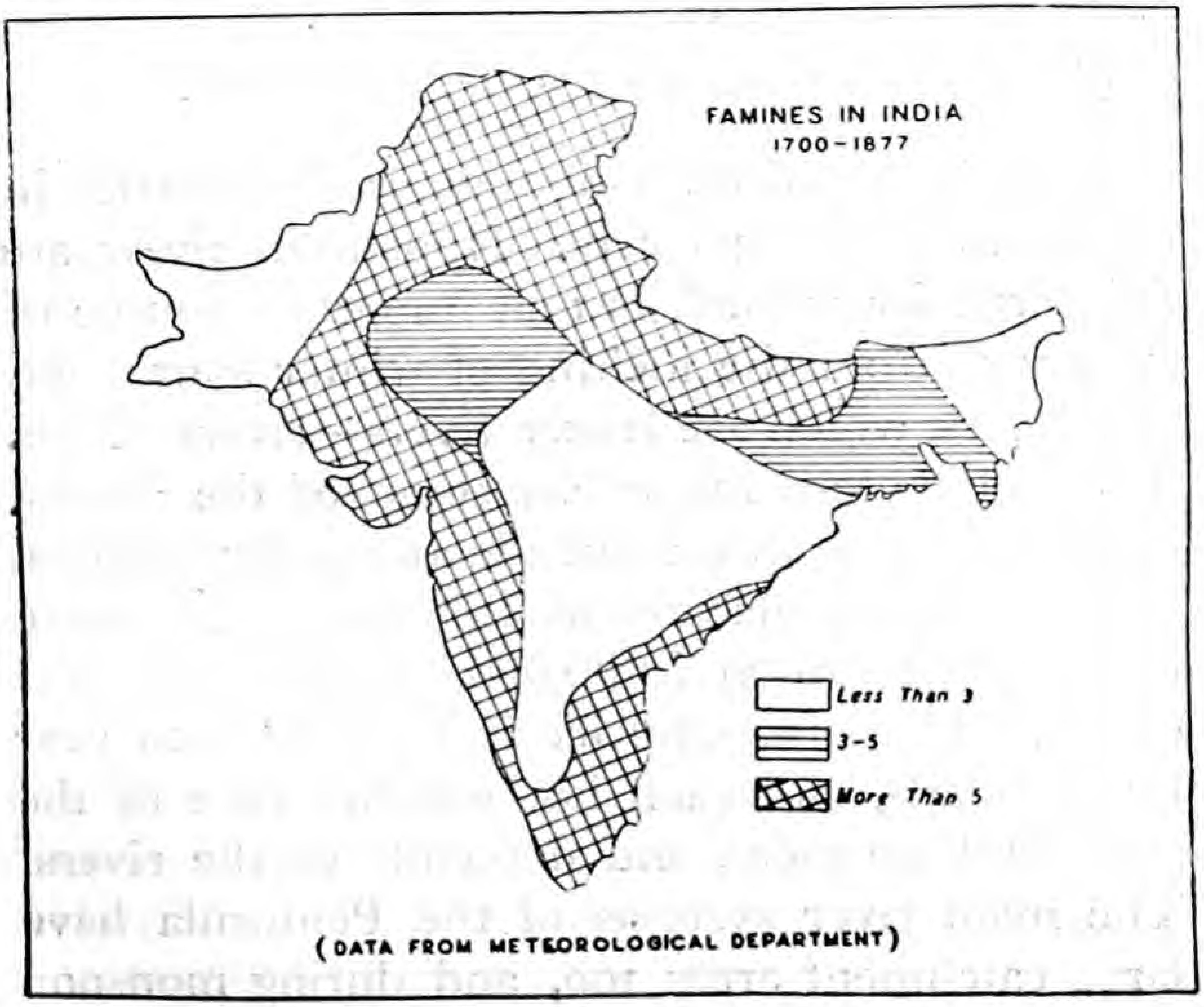


FIG. 4

existing water-supply will have to be developed in the following main ways:

(1) *By constructing barrages* (low walls) *across rivers* which have not already been tapped, and so irrigating lands at present only watered by rainfall.

(2) *By storing water* in hill and mountain valleys behind higher walls or dams, to hold up water for use during periods of low rainfall.

(3) *By making more use of ground-water* (water held in the soil and rocks) by means of open wells and tube wells.

(4) *By improving the fertility of the soil.*

India is one of the most favoured countries in the world with its rivers. Himalayan rivers are fed partly by rainfall, but an important source of supply is from the melting of winter snows and of glaciers, which are frozen rivers—rivers of ice. The Karakoram range has some of the largest glaciers in the world outside the polar regions, and the major glaciers of this mountain range may contain up to 1,000,000,000,000 cubic feet of ice. The snow and ice is renewed each year by snowfalls, and each hot weather part of the snow and ice melts and descends to the rivers. The main river systems of the Peninsula have large catchment areas too, and during monsoon floods more than a million cubic feet of water may flow along them every second.

As has already been stated, the first method enumerated above is the one which has been most adopted here, particularly in Sind, West and East Punjab and the United Provinces; and the barrages, such as that at Sukkur, are some of the major engineering structures of the world. In the hilly region of South India there are, however,

some important projects involving the construction of dams. One of the most important is the Mettur Dam of Madras Province which holds up water in a reservoir which is 60 square miles in area and has a volume of 96,000,000,000 cubic feet. This dam has a maximum height of 176 feet and a length of 7,070 feet. The Central Government, and several of the Provincial Governments, are now carrying out studies of other projects, both in the Himalayan foothills and in the peninsular plateaux, which will be even larger than that at Mettur. These projects are known as 'multi-purpose' projects because they serve the community in several ways.

Firstly, water is stored that can be used for irrigation during times when the rainfall is small. The main dam of the Hirakud reservoir, Mahanadi river, will be 3 miles long and will store 230,000,000,000 cubic feet of water. This water will be used to irrigate 875,000 acres of land at present only receiving rainfall. Two crops will be irrigated, and the total irrigated area of these two crops will be 1,100,000 acres. It is estimated that the additional yield in food-grains resulting from this irrigation will be 340,000 tons annually, valued at Rs. 3·5 crores.

Secondly, water in falling can be made to do work. For centuries people who have lived in

hilly regions have ground their wheat by diverting water from streams down hollowed tree-trunks so as to drive water-wheels. In large dams water is

Photograph by G. C. Chaterji of the Geological Survey of India
Jog Falls near Gersoppa, Mysore State

passed down large steel pipes built into the dam itself to drive turbines in a power-house at the foot of the dam. The turbines in turn operate dynamos for the generation of electric power. The ultimate capacity of the power-houses connected with the Hirakud Project will be 475,000 kilowatts.

Thirdly, as water is let out of the reservoirs during the hot weather to canals and through the

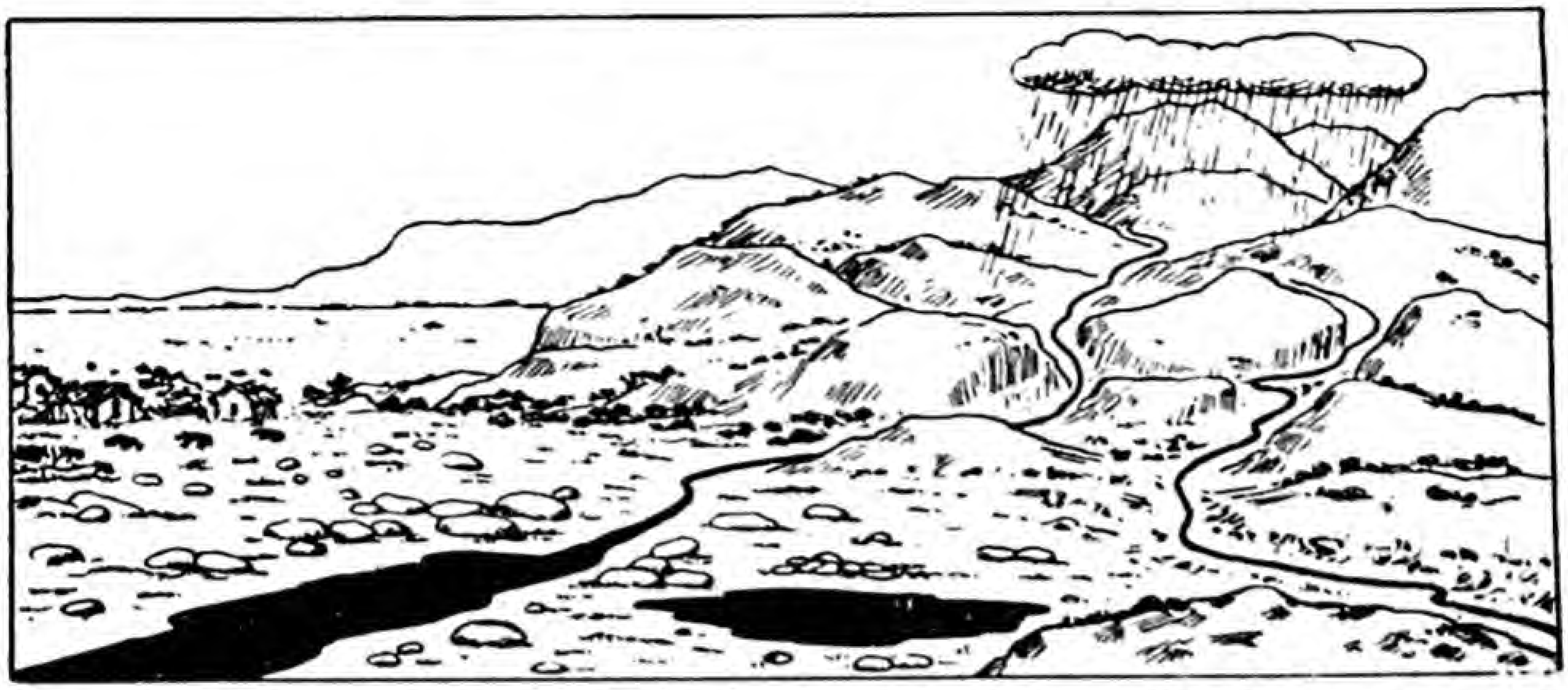
power-houses, the levels of the reservoirs drop, and space is left for the absorption of monsoon floods which must first fill up the reservoir before any excess water spills over the dam. This is known as 'flood control', for it protects the countryside from the disastrous effects of floods.

Fourthly, most rivers in India have such a small dry-weather flow that only the smallest boats can be navigated up them. After dams have been constructed, the dry-weather flow is increased, the water in the rivers is deeper, and larger boats can be used. The present dry-weather discharge of the Mahanadi at Hirakud is about 2,000 cusecs (cubic feet per second), and this flow is distributed over a wide river valley. When the Hirakud dam is completed, the regulated flow of the river will be about 10,000 cusecs during the dry months.

IV

Two disadvantages arise, however, from the construction of dams. In many parts of India the most fertile lands and populated areas lie next to the rivers. The formation of a reservoir means that these lands may be flooded out and the population must be placed elsewhere. Since, however, a greater area of new land is put under cultivation than the area actually flooded by the reservoir, the net gain to the community is large. The

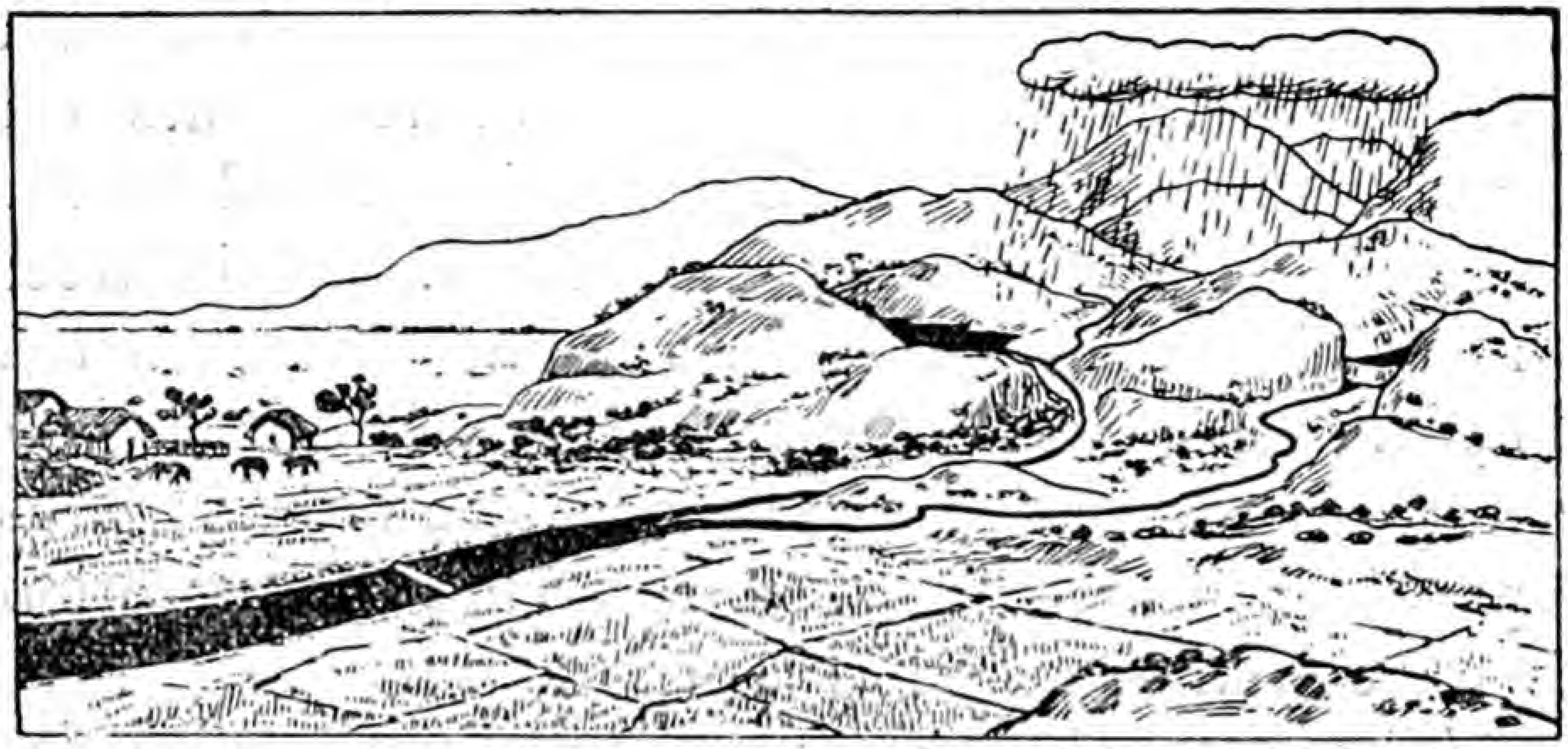
engineers have to study the problem with great care so as to find the most suitable height of dam and quantity of water which will be stored so as



An uncontrolled river washes away valuable soil after rain, and dries up when there is no rain. It makes marshes and deserts.

to cause the least displacement of population and to irrigate the maximum area of new land. As an example may be mentioned the proposed Tikapara dam, which will be constructed on the Mahanadi river below the Hirakud dam. If this dam were to be 330 feet in height from low-water level, it would be able to generate 2½ million kilowatts of electric energy. But the reservoir behind the dam would submerge 1,825 square miles of valuable land and it would cost a great deal to compensate the many people who would be compelled to leave their lands and houses.

It is possible therefore that the engineers will restrict the height of the Tikapara dam to 180 feet above low-water level, in which case the area



A river controlled by dams flows throughout the year and the country through which it flows can be cultivated.

submerged by the reservoir will be 350 sq. miles and the power generated will be 432,000 kilowatts.

The second disadvantage is that dams hold back much of the clay, silt and sand which is normally carried by the rivers, when in flood, down to the sea. In the course of time, perhaps in 200 years, some of the reservoirs will thus become largely filled by alluvial river deposits. In many dams of low height it is possible to swill out the finer silt by means of special sluice gates which are built in the dam, but it has not yet been possible to design such gates in high dams.

The only means at present known of preventing the silting of reservoirs is by constructing other dams on the tributary rivers upstream of the main reservoir, but these reservoirs will also tend to become silted, and in the course of time the river basin will consist of a series of reservoirs the capacities of which have been diminished by the silt which has partially filled them. An indirect method of decreasing the amount of silt carried by the rivers is by preventing soil erosion, by terracing of fields and proper afforestation. This problem of soil erosion is receiving the attention of the Damodar Valley Corporation.

These drawbacks are not sufficient reason for not building dams in river basins. The vitally serious fact facing the Governments of India and Pakistan is that more land must be put under cultivation as soon as possible, and more electric power must be developed, to provide for the crop and industrial needs of the growing population. It will be many years before atomic power can replace the diminishing power from storage reservoirs.

V

The following is a list of the main projects which are now under investigation by departments of the Central and Provincial Governments of India:

PROVINCE		NAME OF PROJECT	CAPACITY OF THE RESERVOIR (*acre-feet*)	AREA WHICH WILL BE IRRIGATED (*acres*)	POWER TO BE GENERATED (*kilowatts*)
W. Bengal	...	Mor	1,000,000	600,000	4,000
W. Bengal Bihar	...	Damodar Valley	4,700,000	760,000	350,000
U.P. Bihar	...	Rihand	9,000,000	625,000	170,000
U.P.	...	Nayar	1,400,000		100,000
Nepal Bihar	...	Kosi	11,000,000	3,000,000	1,800,000
E. Punjab	...	Bhakra	3,500,000	4,500,000	300,000
C.P., C.I.	...	Narbada	23,000,000	3,700,000	1,000,000
Bombay	...	Tapti	3,000,000	700,000	48,000
Orissa	...	Hirakud	5,300,000	1,100,000	475,000
Madhya Bharat	...	Chambal	5,000,000	200,000	200,000
Madras	...	Ramapadasagar	12,000,000	1,600,000	75,000
Madras Hyderabad	...	Tunghabhadra	2,600,000	300,000	70,000
		TOTAL ...	81,500,000	17,085,000	4,592,000

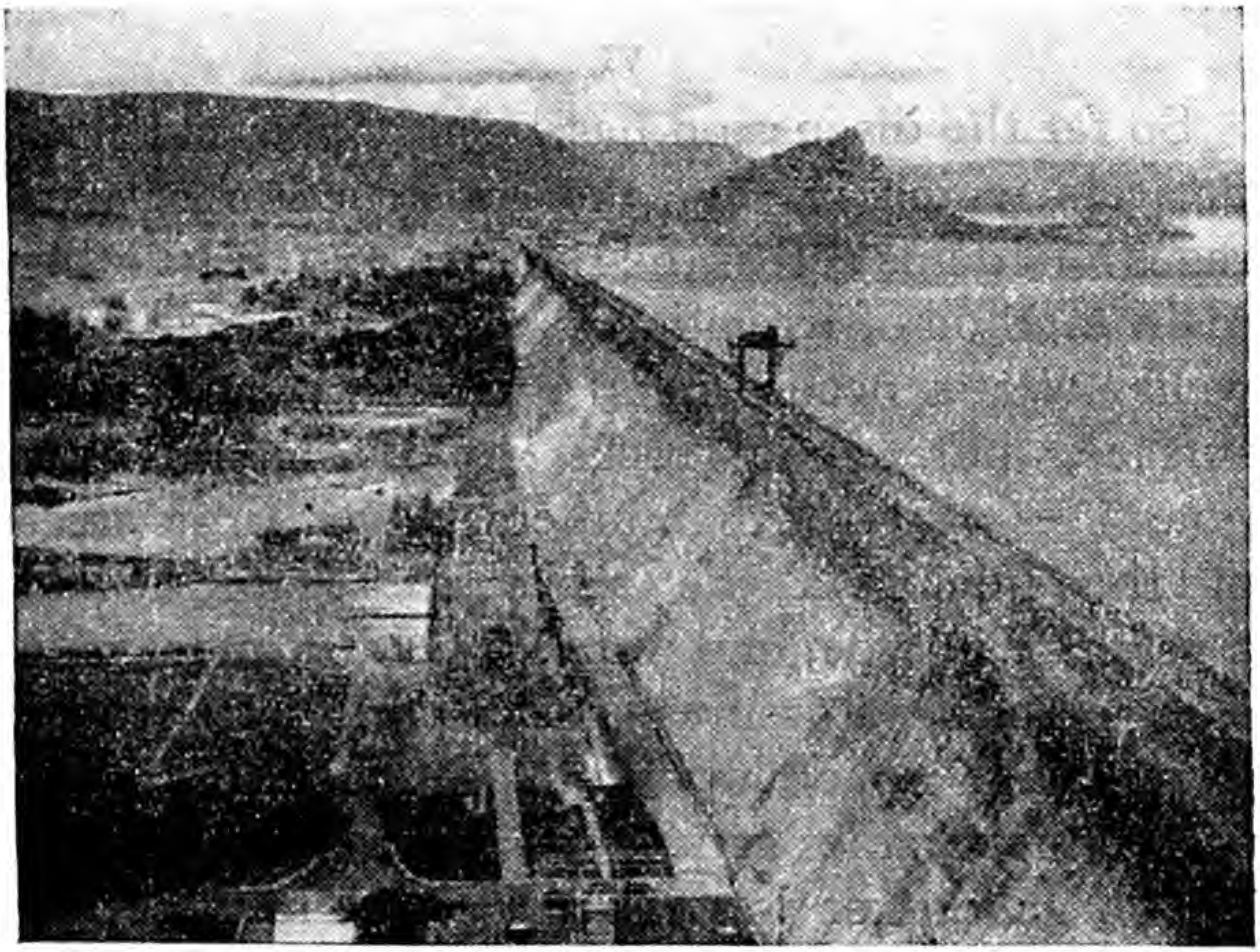
The water unit used in irrigation is known as an 'acre-foot'. This is equivalent to the spread of water one foot in depth over an area of one acre, and is 43,560 cubic feet. Neglecting the Nayar Project, for which there are at present no data about the area which will be irrigated, it is seen from the table that 80 million acre-feet of water will be stored by 11 of these projects in order to

irrigate 17 million acres of land. This means that the average depth of irrigation water which will be added to the fields will be about 4½ feet, although actual depths in different projects vary according to the particular climate of the neighbourhood and the nature and number of crops to be irrigated. If there were no reservoirs the land would need on the average 56 inches of rainfall every year at the actual seasons required by the crops. It has been seen above how variable the climate of India and Pakistan is. No areas in Pakistan receive so much rainfall, and even in the wetter regions of India there are many years when the rainfall is either deficient or comes at an inopportune time.

The dams proposed for these projects vary in height, from 150 to 300 feet in the Peninsula to as much as 750 feet in height from low-water level in the case of the Kosi dam in Nepal. The dams in the valleys of the Damodar and Mahanadi basins will be partly earth dams, like the earth bunds so well known already in India, with concrete sections where the diminished flood waters will pass over. All the high dams of the Himalayan foothills, the Narbada and Godavari, will be constructed of concrete.

To construct a dam of the great size of that proposed on the Kosi river it is necessary to

make very detailed studies of the rock foundations by means of tunnels and borings in order to prove the location of weak zones. If such zones



Photograph by G. C. Chaterji of the Geological Survey of India

Stanley Dam at Mettur in Salem District, Madras

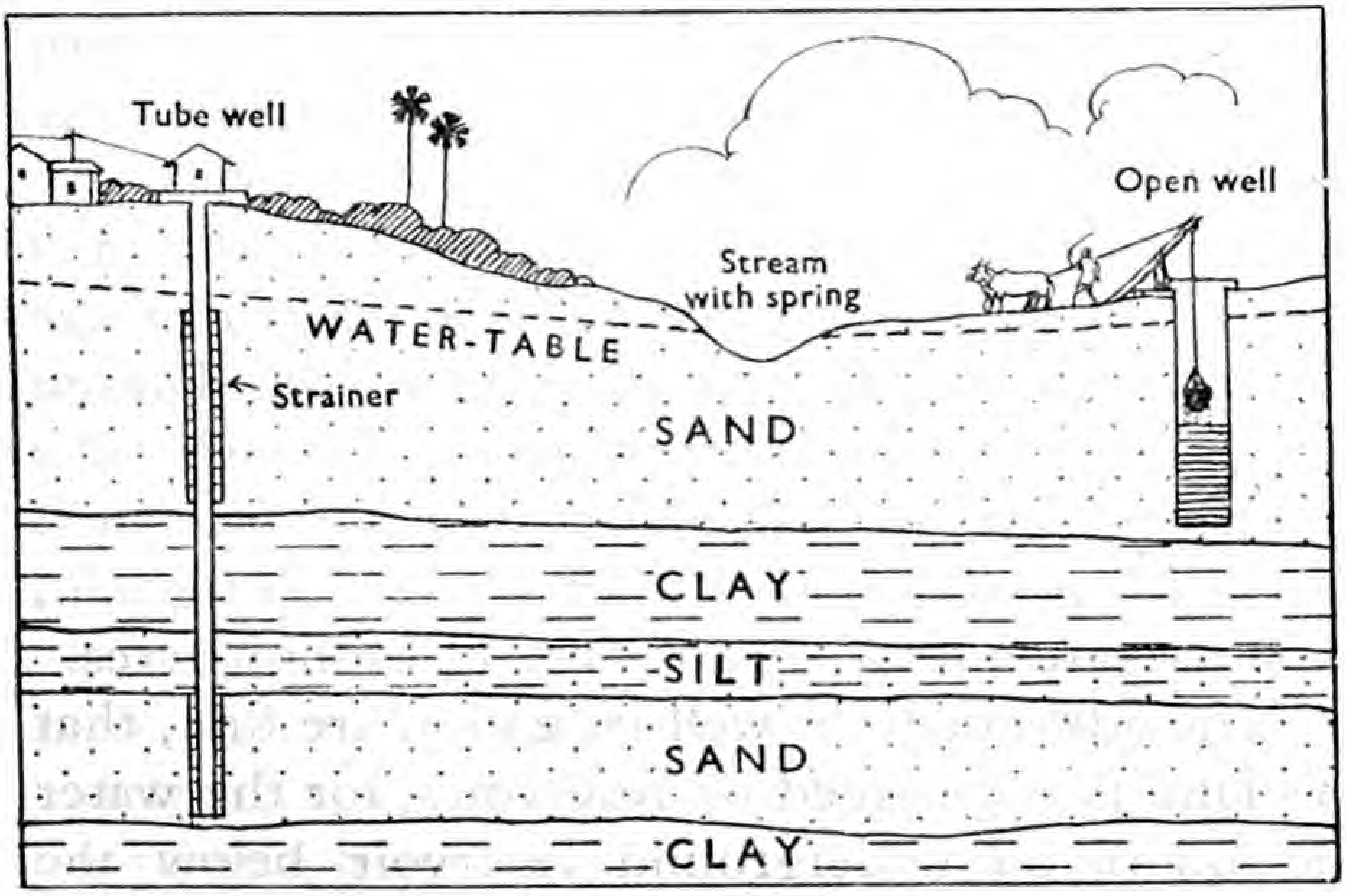
are found they will have to be excavated, and the holes filled up with concrete. Since almost 2½ million tons of cement will be required for the Kosi dam the geologist must search for the best limestones, suitable for the manufacture of cement, in the neighbourhood. If no limestones are available locally, it will be necessary to bring

cement from existing factories at some distance from the sites, which means extra cost in transport and makes the final cost of the project greater.

VI

So far the discussion has been concerned with projects which involve the construction of barrages and dams across the river valleys. The other main method of irrigation is to obtain water from wells. Water occurs in all rocks near the earth's surface, but some rocks hold much larger quantities of water than others. Over large areas of the Peninsula the rocks are granitic and crystalline in type, and water is held in them only along cracks and fissures, and in parts softened by weathering. Deep wells of large diameter may under favourable conditions yield as much as 10,000 gallons of water per hour, but these are exceptional, and generally it may be said that the average yield from open wells in rocks of granitic type is less than 1,000 gallons per hour. There are, however, extensive regions in India and Pakistan, particularly along the Indo-Gangetic plain, where soft alluvial deposits of gravel, sand, silt and clay occur to a great depth. The alluvium of the Lahore basin is thought to be over 4,000 feet thick, while that in the centre of the Ganga basin is probably over

6,000 feet in thickness. These alluvial strata, laid down in geologically recent times, contain very large quantities of water which is held in the spaces between the mineral grains and particles, like water in a sponge. Although much water



Three sources of water are shown here: a stream, an open well and a tube well. The stream dries up during parts of the year, and it is difficult to distribute its water to the surrounding (higher) fields. The open well yields about 8,000 gallons per hour. The tube well, which goes down to the water confined under the clay, provides three or four times as much, and is situated on higher ground.

occurs in silts and clays, it cannot unfortunately be yielded easily to wells because of the fineness of the particles and minute size of the pore spaces.

But sands and gravels contain large quantities of water that can be tapped by wells.

There are thousands of open wells in these alluvial tracts of the United Provinces and Bihar, but the best method of obtaining large supplies of water is by means of tube wells, which are tubes from 2 inches to 18 inches in diameter with wire-mesh strainers placed in those parts of the tube which pass through sands and gravels. In India most of the tube wells average 200—300 feet in depth, but deeper wells of 1,500 feet are known. In the western districts of the United Provinces there are now about 2,000 such tube wells, worked by electrically driven pumps, which give an average yield of 20,000 to 30,000 g.p.h., and irrigate a total area of over 1½ million acres.

The advantages of well-irrigation are first, that no land is submerged by reservoirs, for the water occurs in an underground reservoir below the fields and houses. Secondly, surface reservoirs in hot climates lose large quantities of water by evaporation, particularly under hot, dry winds. It has been estimated that the quantity of water lost by evaporation in a single year from surface reservoirs in India and Pakistan is generally between 5 and 6 feet. With a reservoir such as that at Mettur, Madras, with an area of 60 square miles, this means a loss of water which

could otherwise have been used to irrigate an additional 40,000 acres of land. Thirdly, underground reservoirs never silt up and, provided they are not overpumped and the climate does not change, may be said to last for ever. We know from historical records that wells have been used for thousands of years. The ground water is replenished every year by seepage of rain from the surface of the ground down to what is known as the 'water-table' or upper surface of rock or alluvium which is saturated with water.

So long as observations are made of the water-table, by keeping records of the level of water in the wells, and the water-table is found to recover its old position after seasons or years of heavy rainfall, there is no danger of exhausting the underground reservoir.

Indeed, just as full use is not made of a surface reservoir unless water is drawn off by canals and room is left in the reservoir which can be filled during the wet season, so also it is sound practice to pump out water from an underground reservoir in order to allow space for replenishment during wet seasons and years. In some parts of California the water-table did sink by as much as 150 feet, but this was because wells were sunk indiscriminately and more water was taken out of the ground than

went into it from rain and river seepage. This fall in the water-table has now been checked by deliberately spreading water over the ground so that the underground reservoir receives larger quantities.

Areas which are likely to be developed in the future by means of tube-well irrigation are parts of the alluvial basins of West and East Punjab, eastern U.P., Bihar, Bengal, the Madras coastal region, the alluvial tracts of the Narbada and Tapti valleys, Sind and Baluchistan.

Tube-well irrigation is only possible on a large scale if cheap electric power is available. If electric power is too expensive the cultivator has to pay more for his water than he can afford, and tends to grow only the most paying crops, such as sugar-cane. Cheap power should be available from the projects which were described above. Water, stored by dams, provides the power to generate electricity, and the electric power is used to pump out more water from underground reservoirs.

VII

Lastly, crop yields can be greatly increased by the scientific use of fertilizers, if care is taken to use the correct type of fertilizer for each type of soil. The following table gives the yields, in

pounds of crop per acre, of rice and wheat in different countries:

	RICE lb per acre	WHEAT lb per acre
Japan	3,444	1,713
Egypt	2,998	1,918
China	2,433	989
U.S.A.	2,185	812
India	1,240	660

It is seen that India has the lowest yield per acre, which is due mainly to the use of dung as fuel rather than as manure. The high yield of rice in Japan results from the use of night-soil or human sewage in the fields. The Government of India is now constructing a large plant at Sindri, near Calcutta, for the manufacture of ammonium sulphate. This chemical, which is rich in nitrogen, is a valuable fertilizer.

These are some of the aspects of the water problem in India and Pakistan. Perhaps some of you will help in constructing the projects and improving the condition of the people.

BIRD-WATCHING

by

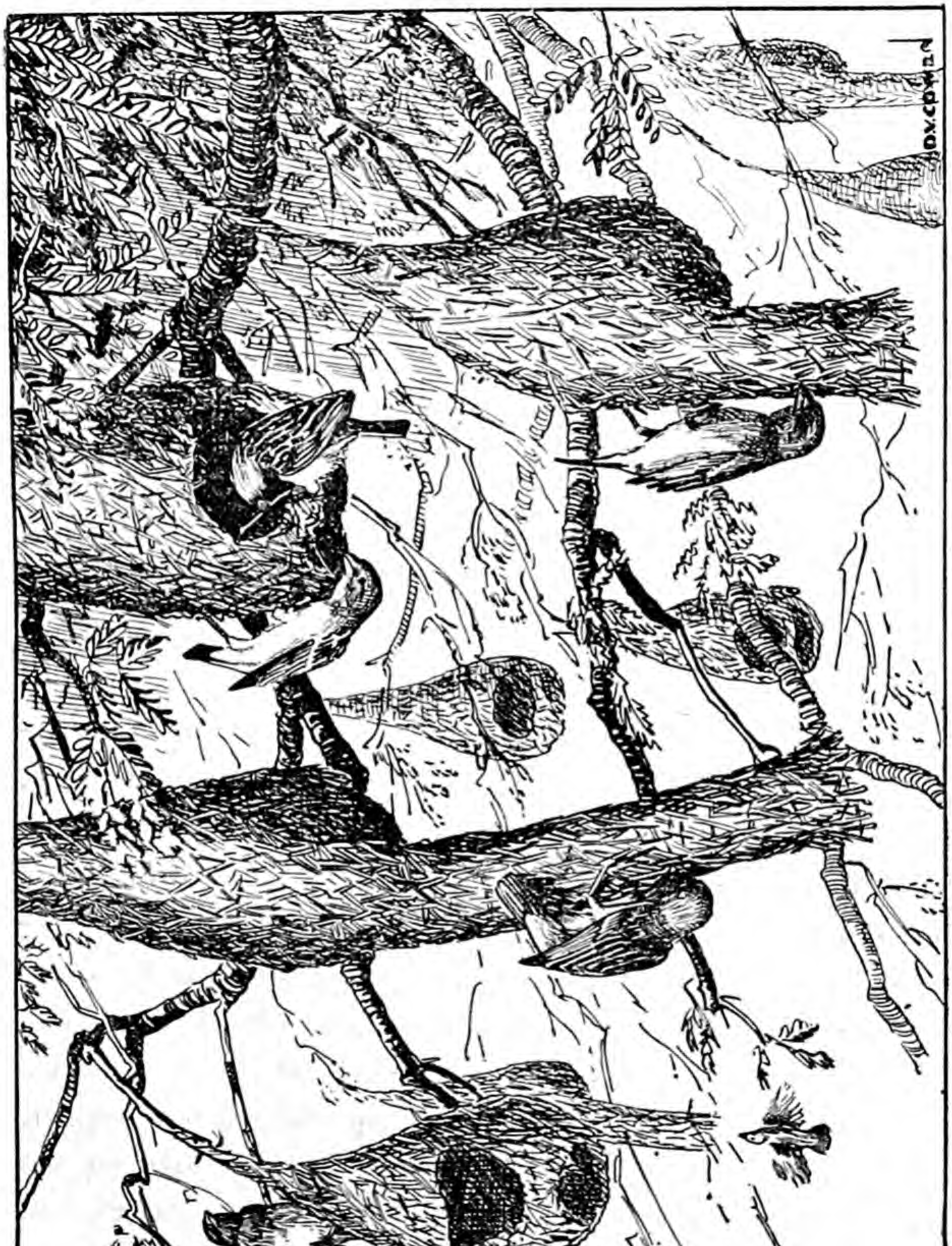
SALIM AL I

Author of 'The Book of Indian Birds' and 'Indian Hill Birds'

I

IN MY many years of bird-watching, the experience which has probably given me the greatest satisfaction was the one that led to the unfolding of the peculiar nesting habits of the Weaver Bird or Baya. One is seldom so fortunate as to be able to pursue an investigation uninterruptedly in its natural sequence from beginning to end. Usually one has to be content with odd bits of observation gleaned from time to time, perhaps extending over several years, and which leave many gaps in the continuity when pieced together.

I happened to be staying over the monsoon months at a place called Kihim on the mainland across Bombay Harbour. On one of my rambles I discovered a babul tree standing in thigh-deep water in the middle of a monsoon-filled depression. On this tree was an active colony of weaver birds busy building their wonderful bottle- or retort-shaped hanging nests, which are certainly amongst the most clever examples of bird architecture. Here were nests in every stage of construction



Colony of cock weaver birds at work. Note prospecting female on nest (top centre)

—from those in which the first foundations had just been laid to fully completed ones with long entrance tubes which were already occupied by female bayas sitting on their eggs. The nests, as I have since ascertained to be invariably the case in areas subject to the south-west monsoon, were all hanging on the eastern or leeward side of the tree. The treetop acts as a windbreak and protects the nests against the strong gales that blow at this season. This was just the opportunity I had been looking for, and I forthwith decided on my plan of action. I had some straight saplings cut down, and with the poles contrived to rig up what was in effect a cross between a high stool and a step-ladder. It had a platform on top just large enough to accommodate a single person perched on a wicker stool, at a height almost level with the nests. Around the platform were fixed upright leafy branches to form a 'hide' from within which I could observe and photograph the birds without disturbing them. This step-ladder hide was installed in the water opposite the nest colony at a few feet's distance, and for the next $2\frac{1}{2}$ months I spent from half an hour to 3 hours on it daily or on every other day armed with binoculars, notebook and camera, observing and recording the activities and photographing the birds. The total time

spent within the hide was something approaching 100 hours. These observations brought about a complete change in the views previously held regarding the breeding habits and domestic relations of the weaver bird, and also revealed a number of facts about its life-history that had been little suspected before.

II

Very soon after the vigil began, things started happening in the colony that were quite different from what I had read in the books. For example, there seemed to be none of that connubial co-operation in the building of the nest previously described by one writer after another. Indeed no females at all were to be seen engaged in the actual work. The few hens present in the colony were those already in occupation of completed nests, in and out of which they flew from time to time. All the birds occupied in nest-building were cocks in their bright nuptial plumage, distinguished from the hens by a golden yellow crown and breast, set off by a dark brown patch on the throat. The hen baya is, at all seasons, a plain creature very like the hen House-Sparrow. The cock doffs his 'wedding dress' when the nesting season is over and the sexes then look alike and are difficult to tell apart.

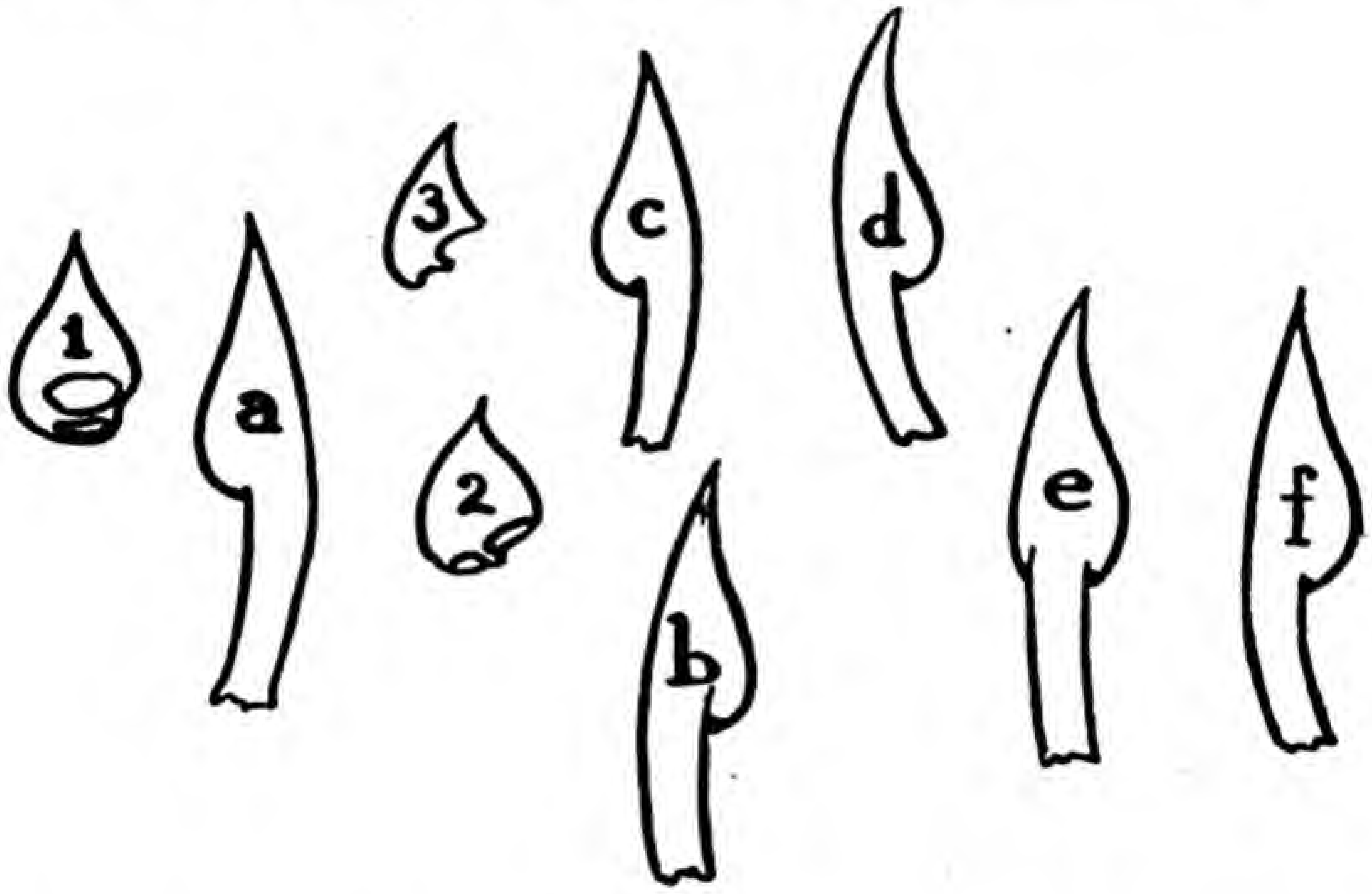
This populous babul colony consisted of a large number of nests. Incessant bustle prevailed as parties of cocks flew back and forth to the neighbouring paddyfields to procure strips of paddy leaf for weaving their nests. The constant movement of the birds accompanied by the noisy chittering, chirping, chorus-singing and fluttering of wings as they worked, made it difficult to mark down any individual with certainty or to guess what his status was in relation to any particular nest or nests. Although one individual of any kind of bird looks superficially like any other, yet a more intimate acquaintance brings out little points in plumage or mannerism which enable individual birds to be recognized quite as surely as human beings. Each individual definitely possesses what may be called personality.

From watching certain individuals day after day, suspicion arose in my mind that the matrimonial relations of the birds were perhaps not so simple and straightforward as the books had described; that they might in fact be polygamous after a fashion. But how was proof to be obtained? If some of the cocks could have been marked in a way that rendered their identity unmistakable, it might be possible to follow the goings-on with greater confidence. Marking of individual birds with aluminium or coloured celluloid rings round

the leg for the study of migration and other problems is now a common practice. This, or the squirting of indelible dyes on individuals, would however have been impracticable at this stage without frightening the birds and disturbing the natural functioning of the colony. Therefore, it was a piece of very good luck indeed that, while reconnoitring the neighbourhood, I came upon a smaller nest-colony on a palmyra palm standing in the midst of flooded paddyfields which in every way presented ideal possibilities as a control colony.

It consisted of six completed nests with elongated entrance tubes, all of which appeared to be occupied by hens. In amongst them there were three other nests, as yet only half built (at the 'bell' or 'canopy' stage), on each of which there was a single cock baya at work. The complexity of the populous colony was here reduced to its simplest form, and this obviously was my opportunity. I set about trying to figure out the exact relationship of each of the builders to the various nests in this group. To this end I drew a rough sketch plan of the colony in my note book (see figure) marking the three half-built nests and their respective builders Nos. 1, 2 and 3. The six completed nests were numbered *a*, *b*, *c*, *d*, *e*, *f*. The behaviour of each cock in relation to all the

completed nests was carefully noted. Among other things, I plotted out which of the cocks could hop on to which completed nests without molestation from his fellow-workers, and where resentment was shown and by which cock.



In the case of the baya a completed nest constitutes the cock's 'territory', and if another cock alights on it, he is promptly assailed and driven off by the owner even though he happens to be working on a different nest nearby. Fortunately for my experiment, one of these three cocks had a deformed tail-feather by which it could always be recognized unmistakably. Closer acquaintance made it possible to distinguish between the two other cocks also with certainty. A couple of hours'

watching on the first day brought me to a conjectural estimate of the ownership of the various nests, and I returned home.

The following morning I was back again at the control colony, and starting afresh on a clean sheet of paper repeated the process of mapping the positions of the various nests and plotting the movements and reactions of the three cocks. The entire procedure was repeated on the third day, and then as a final test again on the fifth day. I then sat down to scrutinize and collate the sketches and notes, and was delighted to find that they entirely confirmed what I had suspected as to the state of affairs in the larger and more populous babul colony. Each of the cocks working on the half-finished nests of the control colony proved to be the owner of two of the completed nests occupied by hens sitting on eggs. Each was no doubt aspiring to entice a third wife, completing his third nest to receive her.

III

How are these wives acquired? The apparent absence of females from the babul colony was at first a puzzling circumstance. All the birds busy building were cocks in full breeding dress, and there was none of that collaboration between the sexes which the older books described. I

wondered where the females were keeping, and when they would appear on the scene. As the nests progressed, and some of them reached the half-way or 'bell' stage, there was suddenly one morning a visitation from a bevy of females. They hopped about from one nest to another, obviously inspecting the handiwork of the cocks and prospecting, as it were, for suitable homes. The arrival of the hens in the colony caused a tremendous stir of excitement in the industrious community of working cocks. They left their weaving and strutted after the hens, pressing their attentions upon them with great impetuosity. The ladies did protest too much, hopping away and from branch to branch in mock attempts to avoid the advances of their suitors.

They remained, however, unshaken in their determination to exploit the possibilities of each nest. They deliberately visited nest after nest, peering within purposefully and entering them in the absence of the owners who had gone off to fetch more material. In the event of a hen being satisfied with a particular nest, she just set about establishing herself in possession. She was chased about by the strutting cock, but she returned again and again and seemed steadfast in her choice. After a good deal of this sort of love skirmishing, the two finally became reconciled

and accepted each other as man and wife. It sometimes happened that two hens set their hearts upon the same nest. Unseemly wrangles took place for possession; bills were plied and feathers flew, and what the ladies said to each other cannot be printed. The victor thenceforward boldly entered the nest and busied herself with 'interior decoration'—finishing off the egg-chamber and making it cosy to receive the eggs.

As soon as the first nest has been approved and accepted by one of these adventuring females, the cock proceeds to complete it and provide the entrance tube, which in some cases is as much as 15 to 18 inches long. With the hen comfortably brooding the eggs within, the cock forthwith selects a new twig nearby and commences building a second nest. In due course, when this nest reaches the appropriate stage of construction, another roving female comes along to inspect it. If it is approved, she establishes herself in possession, thereby becoming his wife No. 2. By the building of three or four successive nests, it often happens that a single cock acquires three or four wives, becoming in the fullness of time the proud father of three or four families almost simultaneously.

Not infrequently, due to some defect in the construction which fails to please the capricious

female eye, a nest goes unaccepted by one visiting female after another. Such a nest is never completed by the cock. He either abandons it and commences a fresh one, or deliberately bites through the suspension so that it falls to the ground. The half-built nests that one invariably finds bestrewing the ground underneath a nest colony of bayas are chiefly such rejections which the builders have jettisoned of their own accord. They are not nests destroyed by rats or other enemies as was formerly believed.

The older writers on Indian birds described the unfinished or bell-shaped nests to be seen in every baya colony as 'cock nests' and gave the romantic explanation that they were specially built shelters or canopies for the cocks themselves to sleep in at night. To find out the truth of this statement, I paid several visits to the main or babul colony after dark. With the help of an electric torch it was ascertained that the cocks did not roost among the so-called 'cock nests' at all. The colony appeared to be completely deserted, and it remained to discover what became of the cocks at night. A watch was kept at sunset. It was observed that soon after the sun went down, successive parties of cocks left the colony and flew off in a particular direction, disappearing over the treetops some distance away. To determine their

goal, a relay of three watchers was posted next evening on the line of their flight, at intervals of two or three hundred yards. As soon as a party of bayas passed over the first stop, he blew on his whistle to warn stop No. 2, who did likewise at the proper time to warn his neighbour farther away. The following evening the relay system was extended further along the flight line, and so on, until finally the birds were tracked down to a thick bed of mangroves at the mouth of a tidal creek two or three miles away. The information thus obtained has since been verified at other nest colonies, and it is now clear that male bayas, and those females not as yet in possession of nests, do not sleep in or near the nest colonies. They remove themselves to suitable reed-beds or mangrove swamps often considerable distances away. These community-roosts are shared by bayas from many different colonies, and also by mynas and other species. A single such roost may provide night lodging to several hundred birds.

This is what makes bird-watching a pursuit for the out-of-doors that is without a rival. You do not have to be a trained zoologist to appreciate birds, neither do you need any expensive apparatus for watching them, though a good pair of field-glasses is always a great advantage. Observations of people who watch birds intelligently are often

of great help to the scientist in solving knotty problems of animal behaviour, since they are usually made from a fresh and totally unbiassed angle which, following accepted theories and hackneyed practices, the scientist may have overlooked.

EXPLORING THE ATOM

by

DR H. J. TAYLOR

Author of a textbook on Physics, working at Wilson College, Bombay and at the Tata Institute of Fundamental Research

I

FROM the beginnings of human thought it has been suspected that matter is composed of small separate particles, which are called atoms. This view was held very clearly by Democritus and other Greek thinkers as early as the fifth century B.C. The word 'atom' is a Greek word, meaning 'uncut' or 'indivisible'. In the first century B.C. the ideas of these early thinkers were expounded by a Roman writer, Lucretius, who wrote a celebrated poem entitled *Concerning the Nature of Things.* He explains how matter must be thought of as made of a very large number of very small atoms, moving about in empty space. Even after two thousand years parts of this poem have a very modern ring.

As Science began to develop, this old doctrine of atoms began to be taken more seriously, and by the end of the twelfth century was generally accepted by the leaders of scientific thought. Sir Isaac Newton has many references to it in his writings. In his *Opticks,* first published in 1704,

there is the well-known passage beginning: 'All these things being consider'd, it seems probable to me, that God in the Beginning form'd Matter in solid, massy, hard, impenetrable moveable Particles, of such Sizes and Figures, and with such other Properties, and in such Proportion to Space, as most conduced to the End for which He form'd them. . . .'

Nevertheless, it was not until the development of Chemistry, in the second half of the eighteenth century, that really strong evidence for the Atomic Theory was forthcoming. The work of the Frenchman, Joseph Proust (1755–1826), made clear the basic fact that when elements combine to form compounds they do so in constant proportions which can always be represented by simple whole numbers. Thus two parts of Oxygen and one part of Carbon give Carbon Dioxide; two of Hydrogen and one of Oxygen give water. In other cases the ratio may be 3:1, or 2:3, and there are compounds which contain more than two elements. But in all cases the ratios can be represented by whole numbers. Why should this be so? Dalton, in the early nineteenth century, seems to have been the first to see clearly the full significance of this fact, which can only be explained on the theory of atoms. Two atoms of Hydrogen and one of Oxygen join to form a little group,

which we call a molecule of water. The water is made up of such molecules, and as the ratio is two to one for each molecule it must also be two to one for the water in bulk. Moreover, since eight grams of oxygen and one gram of hydrogen combine to form nine grams of water, and there are two atoms of hydrogen for each atom of oxygen, the oxygen atom must be sixteen times as heavy as the hydrogen atom. Thus Chemistry gives us the relative weights of the various atoms, though the actual weights cannot be found by chemical methods. These numbers giving the relative weights of the atoms are called the Atomic Weights.

It was found convenient to give the value 16 to oxygen, and to reckon all the others from this value. Many of the atomic weights are then almost exactly whole numbers. Hydrogen has the value 1·008; Carbon, 12; Sodium, 23; Bismuth, 209; and so on. On the other hand, some atomic weights are definitely not whole numbers, such as Chlorine, 35·5; Iron, 55·8; and Mercury, 200·6. The meaning of all this became clear only at a later stage.

II

During the latter half of the nineteenth century the physical study of gases led to other results. In a gas the molecules are flying about freely in

all directions at high speeds. They continually bombard the walls of any vessel in which the gas is contained, and this bombardment accounts for the pressure exerted by the gas. It is not difficult to calculate the speeds with which the molecules must be moving to produce the observed pressure, and we find that the molecules of an ordinary gas, such as the air we breathe, are moving faster than rifle bullets. Further developments of the physics of gases led to a knowledge of the size of the molecules, and of the number contained in any given quantity of matter. This number, now quite accurately known, is exceedingly large. In one cubic inch of water, for instance, the number of molecules is 600,000,000,000,000,000,000,000. An illustration may be helpful. The minute specks of dust which float in a sunbeam are perhaps the smallest particles of matter visible to the naked eye. A thousand million of them would not weigh an ounce. Yet such a speck contains more than a million million atoms. Starting with such a speck, one might distribute an atom to every person living in the world and still have plenty of atoms left. Indeed such a distribution could be repeated every day for about two years before all the atoms were used up. The atoms are therefore very numerous and very small. If a golf-ball were magnified to the size of the

earth, the individual atoms would then look about as big as golf-balls.

Up to the end of the nineteenth century it was believed that the atoms were the final building bricks of matter. There were ninety-two kinds, starting with the lightest, Hydrogen, and ending with the heaviest, Uranium. The atoms were hard, elastic, and indivisible; as Newton had imagined them to be. They were like billiard balls, on an exceedingly small scale. And, in particular, the Hydrogen atom was the smallest and lightest particle in Nature, an ultimate thing, beyond which any further division was unthinkable. All this, after two thousand years of speculation and two hundred years of Science, was regarded as a closed question.

III

Then, suddenly, in 1897, the closed question opened. Sir J. J. Thomson, experimenting on the discharge of electricity through gases, discovered streams of negatively charged particles in his evacuated tubes which were two thousand times lighter than the atoms of hydrogen. These were the celebrated Cathode Rays, and the particles themselves came to be known as electrons. The name is now familiar to every schoolboy, and every amateur radio enthusiast knows how

electrons behave. But the discovery of the electron must be reckoned as one of the major advances of Science. It has opened the way into immense new fields of knowledge undreamed of half a century ago, and of which the end is still not yet seen.

Fifteen years of intense research, after the discovery of the electron, were devoted to elucidating the structure of the atom. Rutherford finally showed that the atom could not be pictured as a billiard ball, but that it is built somewhat in the same fashion as the solar system. At the centre of the region occupied by the atom is the nucleus, a particle far smaller than the atom itself, but in it practically all the mass of the atom is concentrated. This nucleus bears a positive electric charge, and the electrical forces which it exerts enable it to hold in their orbits a number of electrons, which circulate round the nucleus, much as the planets circulate round the sun. The hydrogen nucleus is the simplest possible, and it is called the *proton*. As it carries one unit of positive charge this nucleus is able to maintain one electron in circulation. Helium, the next element, has a nucleus with twice the unit charge, and there are two circulating electrons. The carbon nucleus has a charge of six units and its family of electrons accordingly numbers six. So all the elements fall into order, right up to

Uranium with a nuclear charge of ninety-two units, surrounded by a retinue of ninety-two electrons.

Thus an atom is largely a region of empty space, in which these charged particles move. Imagine the whole atom to be represented by the volume of some large public hall. The nucleus on the same scale would be represented by a pin-head at the centre of the hall, and the electrons by a few grains of sand circulating round it at various distances.

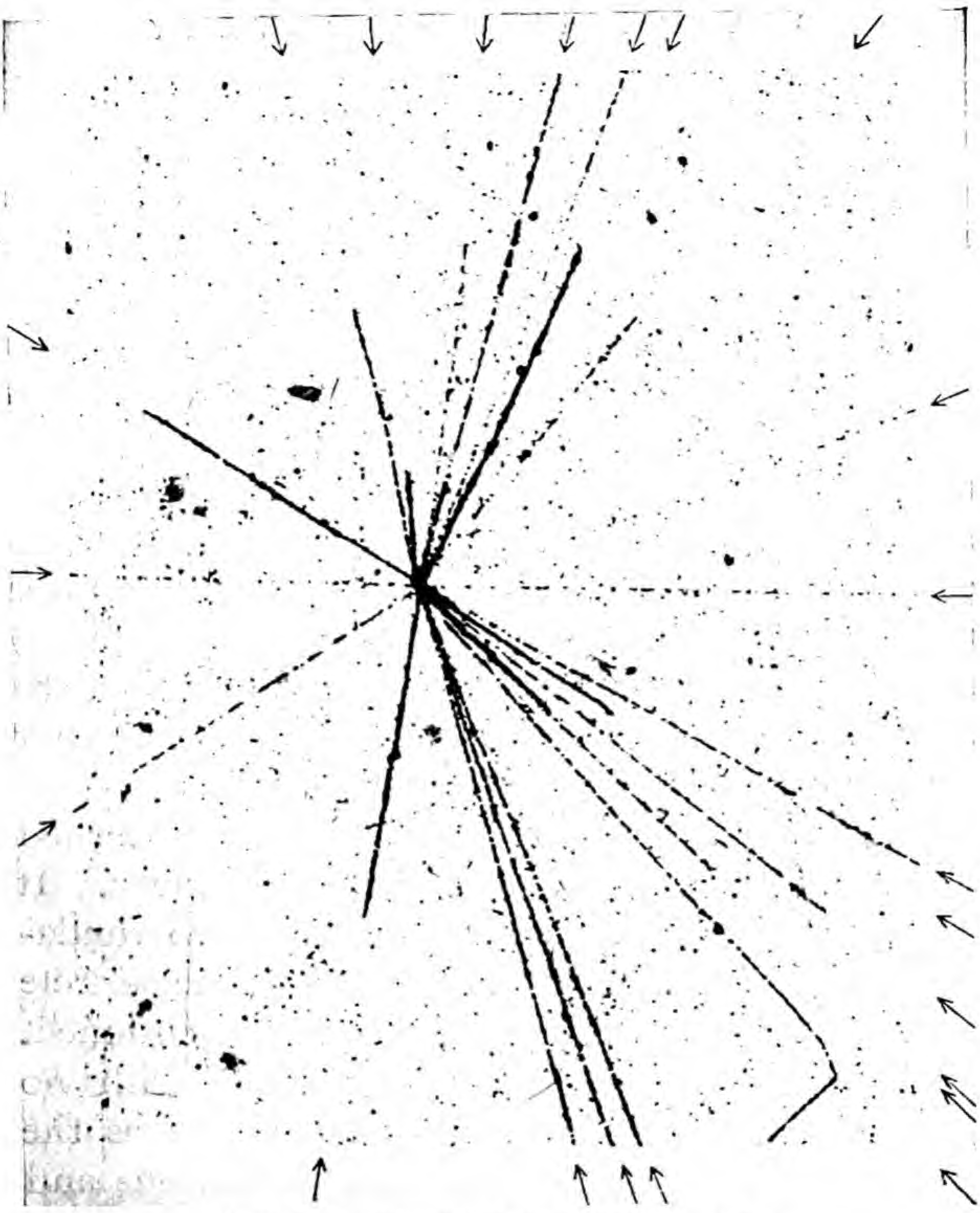
Many years of experimental and mathematical research were needed before all this became clear. One must beware of supposing, however, that the simple picture of circulating electrons conveys the whole truth about the atom. The situation is actually much more complex, but in a broad general way this picture gives a correct idea of the way the atom is built up.

Each electron moves in an orbit with a definite amount of energy. But it is possible for an electron to be knocked out of its orbit or to jump over to a different orbit. When this happens, the atom is either taking in or giving out energy. This energy we may recognize as a pulse of light. When an atom gives out light, an electron jumps down to an orbit nearer the nucleus. At high temperatures, where the atoms are moving at

high speeds and making frequent collisions with one another, electron jumps of this kind become very numerous. That is why a flame or a spark is luminous. By means of the spectroscope physicists analyse this light and discover the various wave-lengths which are present. Thousands of researches have been devoted to such studies and most of our knowledge of the electron orbits and their energies has been derived in this way.

IV

But what of the nucleus itself? For many years the only clue to its structure was that given by the phenomena of radioactivity. There are some elements, Radium and Uranium amongst them, of which the nucleus undergoes a process of breaking up. A particle (known as an alpha-particle) flies out with a speed of some 10,000 miles per second. The alpha-particle is identical with the nucleus of the element Helium. In the case of radium, about one atom in a million breaks up every day in this fashion. But so numerous are the atoms that a single gram of radium emits four thousand million alpha-particles every second. Evidently if the nucleus breaks up, it must have a complex structure of some kind, but to investigate the structure of such a minute body seemed at first an insuperable problem.



THE DISINTEGRATION OF A SINGLE ATOM

When the nucleus of an atom explodes, smaller particles are shot violently out in all directions. The tracks of these flying fragments can be recorded on special photographic plates, and form a permanent record which can be studied under the microscope. The photograph shows a remarkable example of such an explosion, in which the nucleus of a silver atom has been broken up. At least 25 fragments have been recorded.

(From *Nuclear Physics in Photographs*, by C. F. Powell and G. P. S. Occhialini, by courtesy of Professor C. F. Powell.)

Lord Rutherford made the first advance. He allowed the alpha-particle from radium to fall on other matter and observed what happened. There is, of course, no way of aiming an alpha-particle at a nucleus, and the chance that an alpha-particle will score a direct hit on a nucleus is very small indeed. But fortunately these radioactive elements give a copious supply, and by using millions of alpha-particles we can occasionally observe this rare event, a direct collision. Rutherford found that the impact can provoke the disintegration of the struck nucleus. With Aluminium, for instance, the nucleus throws out a proton with high energy, and similar processes happen with other elements.

From such beginnings we have at last learned something of the structure of the nucleus. It appears that we are concerned with two fundamental particles. There is the *proton*, the particle with unit positive charge, already mentioned. There is also the *neutron*, a particle with no charge, but having about the same mass as the proton. Atomic nuclei are made of protons and neutrons.

A single proton forms the nucleus of hydrogen. Two protons cannot stay together, as they repel one another, but if two neutrons are supplied the whole group of four particles makes a stable unit

which is in fact the alpha-particle, the nucleus of Helium. So with the other elements. The Carbon nucleus has six protons and six neutrons. The positive charge on its nucleus is therefore six units, but the mass is twelve units. The heavier nuclei are not stable unless they have more neutrons than protons. Bromine, for example, with 35 protons, has 46 neutrons, giving a mass of 81 units. Lanthanum, with 57 protons, needs 82 neutrons, and so its mass is 139 units. The number of neutrons may vary a little, giving several forms of the same element. There is a form of Uranium with a nucleus of 92 protons and 143 neutrons, making a mass of 235 units. Another form has three more neutrons, so its mass is 238 units. It is not therefore the mass (or atomic weight) of an element which determines its properties; the fundamental thing is the charge on the nucleus, the number of protons. If there are 80 protons, the nucleus is a nucleus of mercury, but the mass may be anything between 196 and 204. Ordinary mercury is a mixture of these various kinds of atom, and when the chemist measures the atomic weight he gets an average figure, depending on the proportions of the different atoms present. This explains why the chemical atomic weights are not necessarily whole numbers.

V

We are now in a position to explain, in broad outline, the recent developments in the field of atomic energy. There is a limit to the size of an atomic nucleus, beyond which it becomes unstable. The nucleus of the heaviest element, Uranium, is very near the limit. A free neutron encounters, let us say, the nucleus of Uranium. Having no charge, the neutron is not repelled, and enters the nucleus. However, the nucleus is in a state where the entrance of even a single extra particle is enough to upset its stability. Lighter nuclei often respond to this situation by ejecting some other particle, and returning to a stable state. The Uranium nucleus, however, behaves rather like a drop of liquid which has grown too large, and splits into two smaller drops. The available protons and neutrons are shared between the two resulting nuclei. Of the 92 protons, if 35 go one way and 57 the other, the result of the fission (as this breaking-up process is called) is that we now have the nuclei of Bromine and Lanthanum. The tremendous force of repulsion between the two positively charged nuclei causes them to fly apart with great energy, which is communicated to the surrounding matter in the form of heat.

But a curious point should be noticed. Bromine and Lanthanum, taken together, require only 46

plus 82, that is 128 neutrons. But the Uranium atom has 143 or, including the one which started the fission, 144. What happens to the spare neutrons? Some of them may be temporarily attached to the new nuclei, but there are always a few left over, which fly in all directions from the scene of the explosion. If the fission takes place in a large mass of Uranium these flying neutrons may themselves produce fissions. Thus one fission may give rise, say, to two more, through the agency of the ejected neutrons. These two may produce four; the four produce

By courtesy of the U. S. Information Service

THE DISINTEGRATION OF MATTER IN BULK

The explosion of a single nucleus can only be detected by very sensitive appararus, but when the explosion spreads to all the atoms in a large lump of matter there is a release of energy on a gigantic scale. This happens in the atomic bomb. The photograph shows the effect produced by the underwater explosion of an atomic bomb at Bikini, on 24 July 1946.

eight, the eight sixteen, and so on. This is what is called a 'chain reaction'. The time between two fissions is less than a millionth of a second, so the process grows at a tremendous rate, and the number of atoms undergoing fission soon rises to billions. An enormous quantity of energy is thus generated in a small quantity of matter in a very short time, and the result is the explosion of the atomic bomb.

It is possible, however, to devise circumstances in which the growth of the chain reaction can be controlled, so that the energy can be liberated slowly. The basic scientific problems are solved, but there are still great technical difficulties to be overcome before the energy so liberated can be put to effective use in industry. This is much too large a question to be discussed here; but we should note that the world's energy comes, for the most part, from coal and oil. Both these sources are limited, and will presently be exhausted. We shall need new sources of energy, and it is more than possible that the energy locked in the nuclei of atoms will be, in a future not far distant, one of the main sources of power for human needs.

CLIMBING

by

JACK GIBSON

Member of the Himalayan and Alpine Clubs and a master at the Doon School, Dehra Dun, when he wrote this

I

HILLS to climb will always excite those interested in search and discovery. Climbing as a sport or pastime is of fairly modern invention, but for ages men must have explored up valleys and over ridges, and climbed hills for the views they could get from their tops. The shepherd with his flocks, the soldier with his armies, the map-maker with his theodolite have climbed hills as part of their jobs. This is easily understood, but there are those who ask the climber who climbs for pleasure what fun he gets out of his arduous sport. There are perhaps as many answers to this question as there are climbers. One looks on the conquest of a summit as an achievement to be proud of; another climbs upwards urged on by the desire to see further; another enjoys pitting himself against difficulties. The first of these will perhaps enjoy the greatest satisfaction at the top, the last as he turns over to sleep at the end of a long day. There are too, of course, the physical enjoyment of climbing, for which you have to be bodily fit,

and the aesthetic satisfaction of the beauties of the scenery you pass through. Perhaps it is unnecessary to try to explain why people climb for pleasure; it is evidence enough that many do, and if you want to discover what there is in it you will have to find out for yourself.

India is a country that offers wonderful opportunities for climbing. First there are the Himalayas and other snow-clad mountains of the north; but even in the south there are high hills and rock cliffs enough for any enthusiast. I myself am lucky to work in a school in the foothills of the Himalayas. Starting from just over 2,000 feet, there are several mountains of over 7,000 that one can climb within a day. Nor is it only mountain peaks that it is fun to climb; to follow a mountain stream up to its source can be an exciting scramble, with little cliffs to surmount and unexpected difficulties on the route. When the school was young we were content with such short expeditions and they laid the foundation for longer ones. Now at half-terms parties will go out for three or four days to explore new routes up hills or across hill-country, and in the holidays various expeditions have been made to the really high mountains. On one of these it is claimed that the highest game of bridge ever was played in a tent during a snowstorm at over 19,000 feet.

Incidents like this make up the local folklore of climbing and build up a tradition which is handed down. There is the story of those who got lost on a 10,000-foot hill and spent the night shivering and wrapped inadequately in the pugree of a Sikh member of the party; and the expedition in which the baggage animals got separated from the rest, who spent a cold and hungry night around a fire of damp wood. When you have enjoyed or suffered these experiences you look back on them with a satisfaction that makes up part of the pleasure of climbing. We must all of us have within us something of an aggressive spirit. We may give vent to this in squabbling among ourselves; how much better to sweat it out on hillsides. When the ancient Hindu religious leaders fixed many of the sacred places of pilgrimage in the high Himalayas perhaps it was partly because they realized that in journeying to them the pilgrim would derive those same benefits that a climber gets from his sport.

II

If you are going to climb, what equipment do you need and how much will it cost you? For simple scrambles up a hill I myself wear gym shoes and carry a walking-stick. Within a day you may also be able to find a cliff where you can

practise rock-climbing, and for this a climbing rope will be necessary, but it is unwise to start roped climbing unless you have the aid of an expert. For all hills below the snow line, gym shoes or lightly nailed boots are satisfactory, but as soon as you have to sleep a night out it becomes necessary to collect a certain amount of equipment. The essentials are a ruck-sack, a light tent, and a sleeping-bag or ground sheet, and blankets. At present some of these are difficult to buy in India but it is probable that they will become easy to find. The ruck-sack should have a light metal frame with a belt that rests on the hips and prevents the sack touching your back and becoming wet through with sweat. It is best to have a tent with a sewn-in ground sheet. Sleeping-bags can be made of kapok in the bazaar. It is important to remember that the top of a mountain is considerably colder than the bottom, and the nights than the days, and anyone who goes climbing even on a short one-day expedition is well advised to carry some warm clothes for higher up.

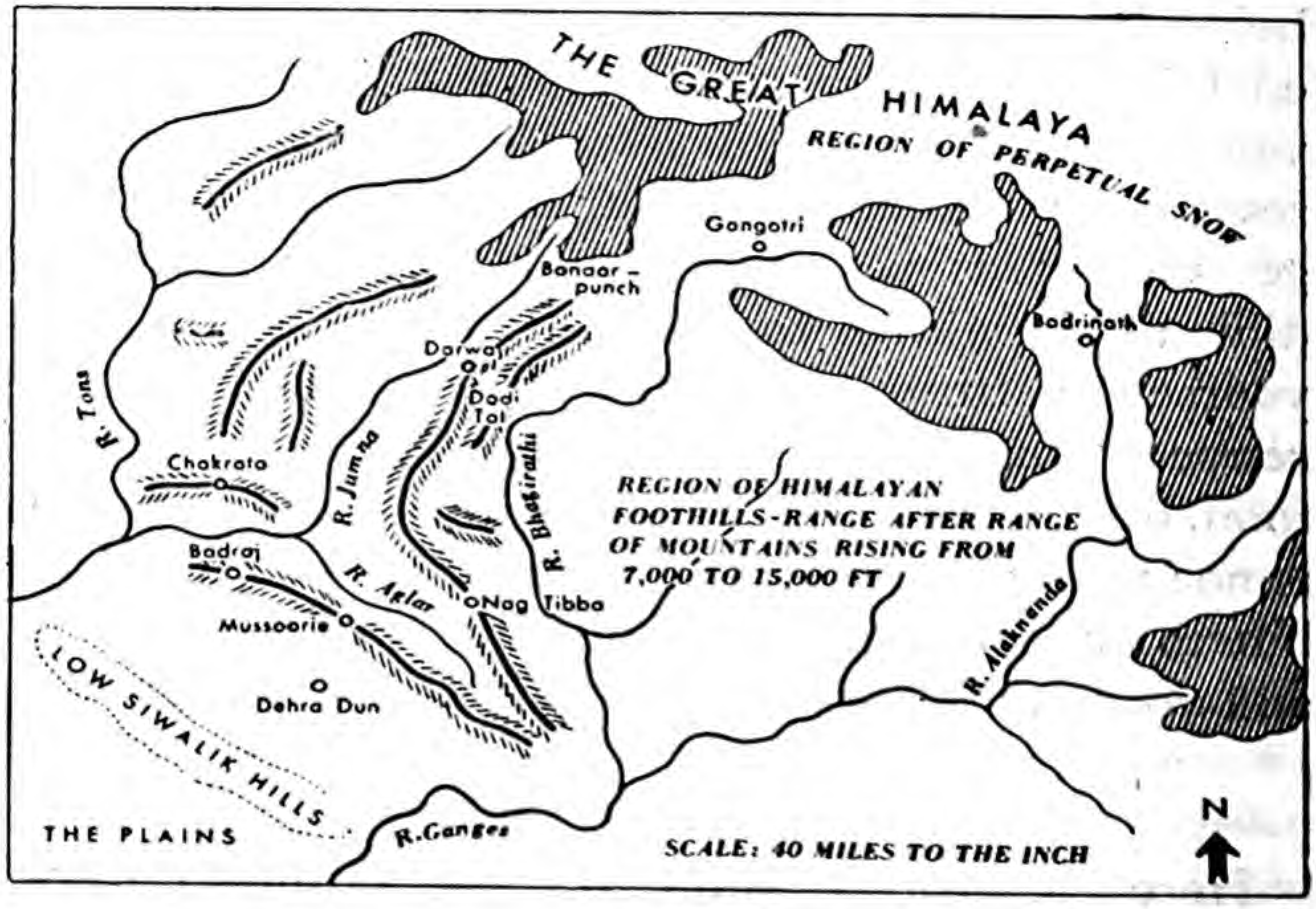
The next thing to consider is food. This should be easy to pack and as nourishing as possible. If you take dal with you, you must remember that it is difficult to cook above 13,000 feet as the boiling point of water is lowered by the decrease

in the pressure of the atmosphere, and you may boil it and boil it without it getting much softer. If you want advice about climbing there are various clubs in India which will be able to give it to you. A new Indian Mountaineering Club is being started and there are also the old-established Himalayan Club and Ski Club of India. If you go climbing on your own in unknown country remember to keep with your companions and not get separated; remember it is easier to get up a difficult slope than to get down it and if you find yourself getting into difficulties it is wise to retrace your steps. A good climber is never foolhardy. But what this chapter sets out to do is not to lay down all the techniques of climbing but to try to make you want to climb yourself, and you will then soon find out how to do it.

III

Here are short accounts of three climbs I have done with schoolboys. The first was to the top of a mountain called Badraj which is at the end of the Mussoorie ridge separating the Dehra Doon from the valley of the Aglar river. We set out one afternoon after school on bicycles with our blankets and food in ruck-sacks, and rode some fourteen miles to the foot of the mountain. Here we cooked our supper and slept till 2 o'clock in

the morning. A hurried breakfast of boiled eggs, bread and butter and strawberry jam, rather sticky at that hour but washed down with hot tea, and we were off.



The climb was first through sal woods. We passed a clearing where cows and buffaloes turned their sleepy heads at us, and the cow-herd from his grass shelter shouted to know what the disturbance was. We climbed past a little hamlet perched on a shoulder where not even the village dogs were awake. We toiled up a spur covered

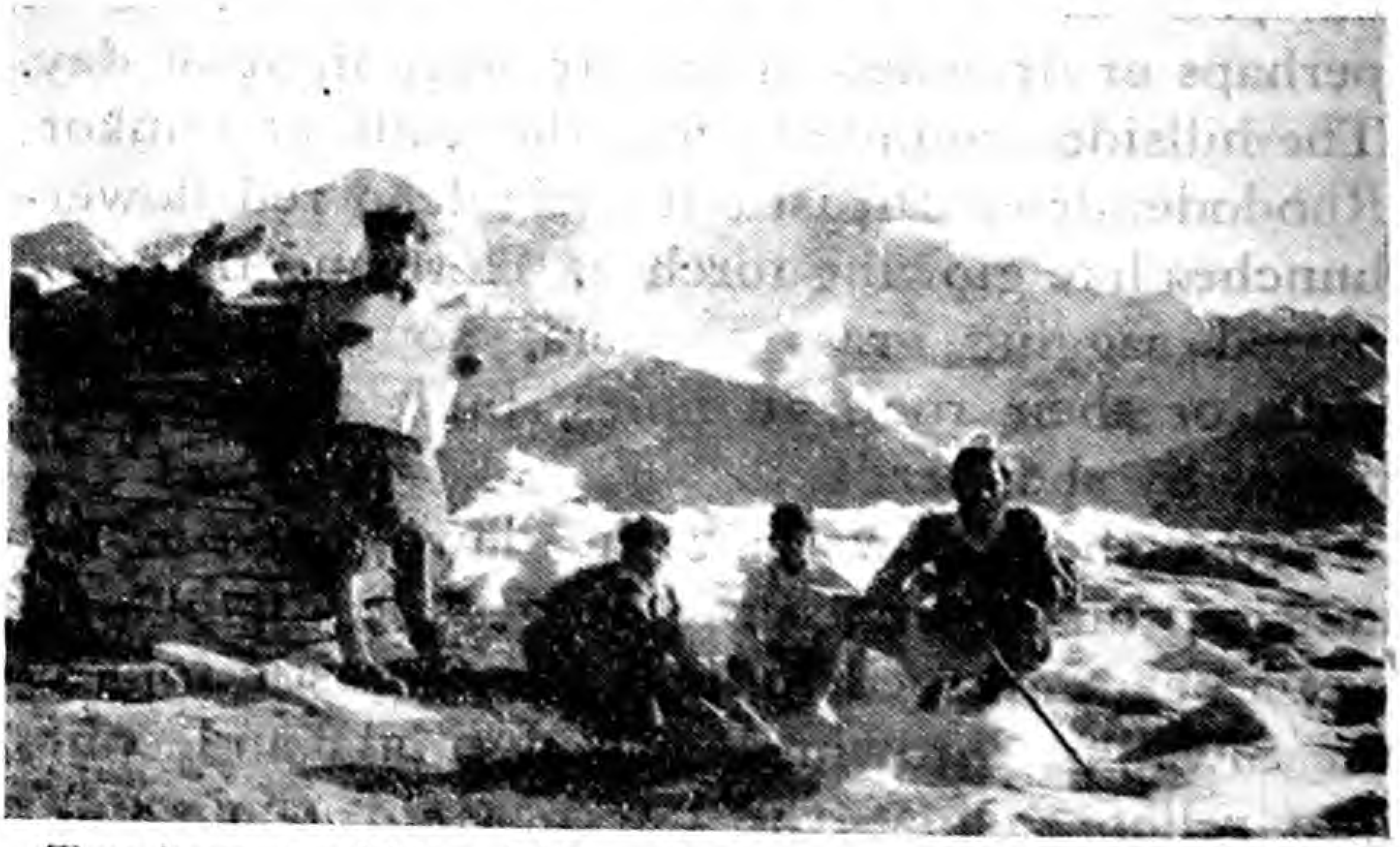
with thorny scrub and came out on to grassy slopes. The white nullahs stretching out across the Doon below us were faintly visible and the lights of Dehra Dun sparkled clearly. Above us a black mass was proclaimed by the optimistic to be the summit. Dawn grew gradually over the Tehri hills and the moon appeared from time to time through its cloudy screen. As we climbed, the eastern sky became tinged with a suggestion of red, while in the west the hills and clouds beyond the Jumna changed from dark grey to deep soft blues. Beneath us the Doon took shape. There were first the river beds, then the hills, one by one the lights went out, switched off perhaps or drowned in the stronger light of day. The hillsides sounded with the calls of chukor. Rhododendrons thrust out their deep red flower-bunches like glowing torches. Here and there we passed sagging grass shelters, some with their walls or their roofs in holes, built the summer before by shepherds.

From the top we saw the dawn but not the sunrise, for the sun came up behind the clouds. Yet a beam escaped to light the fantastic tops of the Siwaliks, throwing their summits and spurs into relief against the darkness of their unlit valleys. We could see the plains beyond the Siwaliks, and the Jumna winding across the

western Doon; the eastern Doon was shrouded in mist. We wondered whether there was anywhere in India so beautiful: 'Sunrise on the hills, mists on the rivers, bird and beast, mountain, plain and forest all giving glory to God in the radiance of the new dawn.'

IV

The second was a fortnight's expedition up the Ganges, across the water-parting between it and the Jumna, and back down the Jumna. For this we had to employ porters to carry our equipment, and that is expensive. It is to be hoped that the



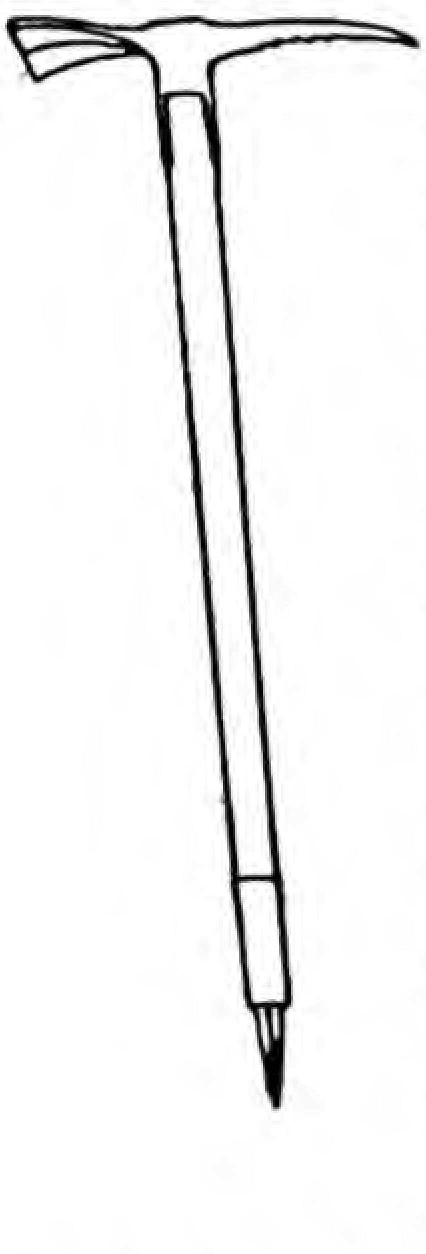
Two boys, aged 14 and 15, and two masters of the Doon School on Darwa, 13,554 feet, the watershed between the Jumna and the Ganges. Bandarpunch is in the background.

time will come when mountain huts and youth hostels will make travel in the mountains easier. We left Mussoorie and three days later reached the Ganges at Dharasu after crossing the Nag Tibba ridge, a favourite three-day excursion from Dehra Dun. From Dharasu we walked along the Gangotri pilgrim route to Uttarkhasi, a beautiful widening in the valley where there are many ashrams and settlements of learned sadhus and which would make a wonderful site for a university in the hills. From there we branched up a tributary river to reach a little lake called Dodi Tal at 10,000 feet, famed for its beauty. Almost surrounded as it is by great mountains, it is black and awe-inspiring if you reach it in the evening when the light is failing.

So far we had done walking rather than climbing, and it is one of the difficulties of the Himalayas that so many days have to be spent working up the lower valleys to reach the high hills. When one day roads are built they will save both time and expense to the tourist. We spent a day catching trout in the lake and resting and sketching the scenery, and the next day started our climb to the ridge between the Ganges and the Jumna valleys. We had seen black bear at the lake and on our way up we twice saw red bear, quite close. The climb was stiff but not

difficult, and we pitched camp on the ridge at 12,000 feet in the early afternoon. The two boys who were part of the party climbed the peak on the ridge at over 13,000 feet and had their first experience of climbing on snow. That afternoon we saw another red bear on the ridge and the next morning we examined its tracks in the snow, and had we not known they were made by a bear we might have suspected that the 'abominable snowman' had paid us a visit.[1]

For a day we walked along the ridge, having to cut steps in places with our ice-axes, for the snow in the gulleys had been frozen into ice which could not be crossed without steps. The second night on the ridge we made camp somewhat lower in the shelter under a col, on a bit of grassy land covered with marigolds and surrounded with flowering rhododendrons. All day we had been finding different flowers, irises, potentillas, gentians, and different primulas. One of the great joys of walking in the hills is the flowers you find by the way. From here the party returned first down to the Jumna and



[1] The local inhabitants believe that human monsters live high up in the snows of the Himalayas. These are the *Kang Admi*, or Snowmen.

then along it and back by Chakrata, passing on the way through the fascinating villages of Jawsar Bawa with their carved houses and friendly hospitality.

In this short chapter it is not possible to describe all the interests of such a trek in the hills: the different kinds of people you meet, the different flowers and trees, birds and animals you discover, the different houses that people live in. There are an infinite variety of interests for anyone who keeps his eyes open.

V

The last expedition I shall describe was an attempt to climb Bandarpunch, a peak of over 20,000 feet. For this sort of trip expensive equipment and experienced porters are needed, and it should not be undertaken without at least one expert in the party. We were two masters, a friend, an old boy and a present boy of the school. Our approach to the mountain involved much the same walking and scrambling as described in the second expedition. We made a base camp at 12,000 feet in a meadow carpeted with wild flowers and used as a pasture by the Gujars, who come up from the plains for pasture for their buffaloes during the rainy season; so we were supplied with fresh milk, lassi and butter.

From here we made a camp at about 16,000 feet to reach which we had had to cross the debris brought down by glaciers, and the icy snouts of the glaciers themselves. We were delayed in this camp by rain and snow for a day, but after that climbed on to the summit ridge and pitched another camp at something over 18,000 feet.

From this we made our attempt on the summit. After a restless and somewhat breathless night we put on our boots, frozen stiff, and roped together. We had an interesting but not very difficult climb up a ridge whose rocks were free of snow. At the top of this two of us decided to turn back as we were not yet acclimatized to the height. You are liable to feel ill the first time you go above 15,000 feet but you get used to the height after a day or two. Two of our Sherpa porters, one of the masters and the old boy continued up the ice slope to reach the highest point that anyone has yet got to on the mountain. The summit seemed attractively within reach, but it was the monsoon season and the weather had started to break. It was decided to turn back, and a subsequent spell of continuous bad weather prevented us from making another attempt. So Bandarpunch, like countless other great Himalayan mountains, remains to attract the adventurer who would say: 'I stood first upon that peak.'

The summit ridge and top of Bandarpunch. The rock ridge on the left is the one described in the chapter.

There is one form of climbing that perhaps I should mention, and that is climbing, and even more exciting descending, on skis. There is no more thrilling sport in the world. In the past it has been centred in Kashmir, but there are other places in the Himalayas suitable for skiing. Indeed the whole range beckons to the young people of India as a playground to be explored, and as a resort where health and vigour may be built up and restored in the fresh air and sparkling sunshine.

CROPS WITHOUT SOIL

by

E. HAMILTON

Of the Hydroponic Research Centre, Kalimpong, West Bengal, and author of 'Hydroponics: The Bengal System'

I

FOR MANY centuries the mystery of how plants grow was a constant puzzle to men. Three hundred years before the birth of Christ, we find the famous Greek philosopher Aristotle, tutor of Alexander the Great, discussing the question of what substances vegetables and other crops used for food.

Unfortunately, Aristotle, who taught in the Lyceum at Athens, seldom bothered to verify his theories by practical experiments, with the consequence that his ideas were often wrong. Nevertheless, the views of Aristotle about plants and how they grew were generally accepted by the civilized world. Though, as we now know, Aristotle was frequently incorrect, men blindly believed his teachings for eighteen hundred years after his death.

Matters continued like this until the Renaissance or Revival of Learning, which gave birth to some splendid scientific men whose discoveries during the sixteenth, seventeenth and eighteenth

centuries changed our ideas of the universe. The foundations of modern chemistry and botany were laid then. The names of Joseph Priestley and Henry Cavendish are familiar to all school boys and girls.

To such pioneers we owe the discovery of hydrogen and oxygen. The composition of air and of water were revealed, much credit going to that great chemist Antoine-Laurent Lavoisier. Despite his services to science, Lavoisier was guillotined in 1794 during the French Revolution. He was not the only one of the early scientists to suffer persecution; in fact three years earlier a mob had set fire to Priestley's house in Birmingham and destroyed his books and apparatus. To this day, men have to fight against heavy odds before they can succeed in convincing people that a new discovery is of value to humanity.

Meanwhile, botanists had begun to produce some sort of order in the classification of plants. Naturally, careful descriptions and drawings were made, and since little study had taken place since the days of Theophrastus who lived from 372-287 B.C., and Dioscorides who wrote in the first century A.D., there was a great deal of work to be undertaken. At this time men seldom specialized in one science only. For instance, Lavoisier was a chemist, a botanist, an astronomer and a geologist

all at the same time! This was possible because science was quite a new subject, and there was not much to learn in each branch. As knowledge increased, men specialized. One advantage which resulted from the former system was that things which were discovered in one branch were quickly used to make fresh researches in another. Thus a chemist, who was also a botanist, would soon apply his knowledge of the composition of water, or of the soil, to a study of the food requirements of a plant.

II

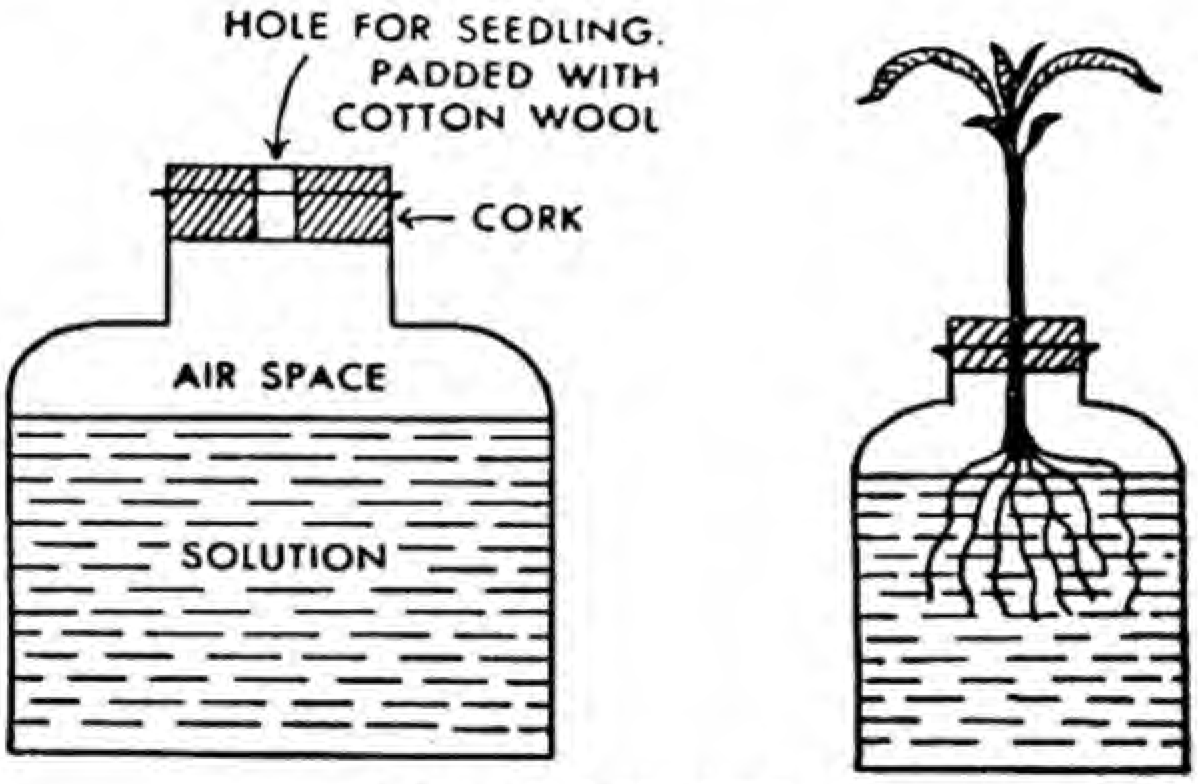
The first person to attempt, by means of a practical experiment, to find out how crops grow was John Woodward. In England in 1699 he grew plants in spring-water, river-water, rain-water and distilled water to discover whether it was the water or the solid particles of the soil that nourished them. Woodward saw that a seed began to develop if given water, but without soil it would soon die from lack of food. Again he found out that in spring-water a seedling lived longer than in distilled water, so he naturally concluded that there must be some substances present in the former which supplied extra nourishment to the plant. Soil without water was valueless, but properly mixed the two seemed to provide a suitable food. Woodward's experiments

were handicapped by lack of equipment, so it was not until the beginning of the nineteenth century that any further progress could be made.

By that time tremendous discoveries had been made in the scientific field mainly due to the work of Sir Humphrey Davy, inventor of the safety-lamp, who had succeeded in bringing to light several of the elements which make up matter. Davy used an electric current in chemical decomposition. The new methods of analysis enabled scientists to split up any compound into its constituent parts. At last it was possible to say what elements had combined to produce any form of matter. Rapidly chemists and botanists began to find the answers to the mystery of plant life. Soil was split up into its various parts, leaves and fruits were analysed to see what chemicals they contained. Obviously, reasoned investigators, if plants contain a certain set of elements they must have drawn these up from the earth through their roots. By 1842 a list of nine elements provided by the soil and believed to be essential to plant growth had been made out.

The next big step forward did not come until 1859 when two Germans called Sachs and Knop began to study the effects of various kinds of soil on different crops. To test each soil would have been a lengthy business taking perhaps twenty

years, so Sachs, who was a botanist, and Knop, whose profession was that of agricultural chemist, studied the list of elements necessary for plant growth. They decided to add different chemicals containing these elements to water. This mixture



WATER CULTURE
Experiment by Sachs and Knop in 1859-65

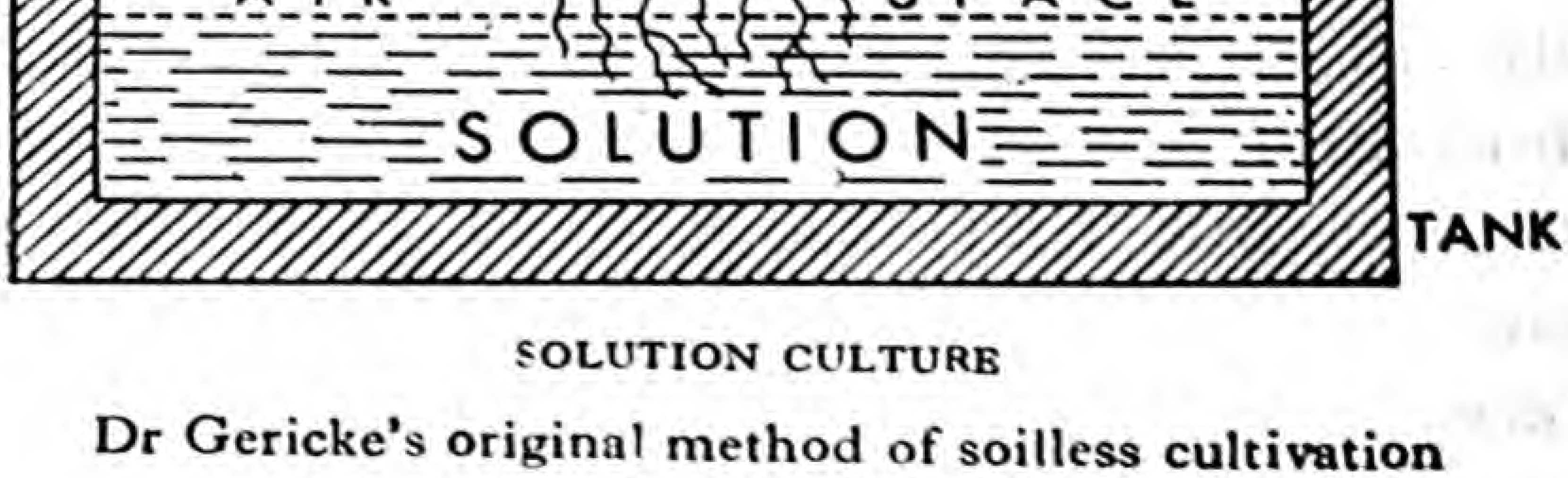
was then poured into jars. Each container had a cork stopper, and through a hole in this, carefully padded with cotton wool, a seedling was inserted with its roots suspended in the solution of chemicals and water.

The experiment was a great success, and not only did Sachs and Knop gain a lot of valuable information about the kind of food that plants like best, but they also proved that any crop could be grown without soil simply by giving it in chemical form the food which it usually drew from the earth through its roots.

The scientists gave the name of 'water culture' to this new method of growing plants, and the mixture of water and chemicals in which the roots were suspended was called the 'nutrient solution'.

III

After the discovery of water culture, more than four hundred chemists and botanists in many different countries worked hard for the next fifty years to improve the new science, so that by 1920 it had become a recognized method of growing plants. But so far no one had suggested that water culture should be used outside the laboratory, so it was unknown to the public. The phrase 'crops grown without soil' was unheard of. Scientists thought that unless special laboratory rules were strictly kept water culture of plants would be

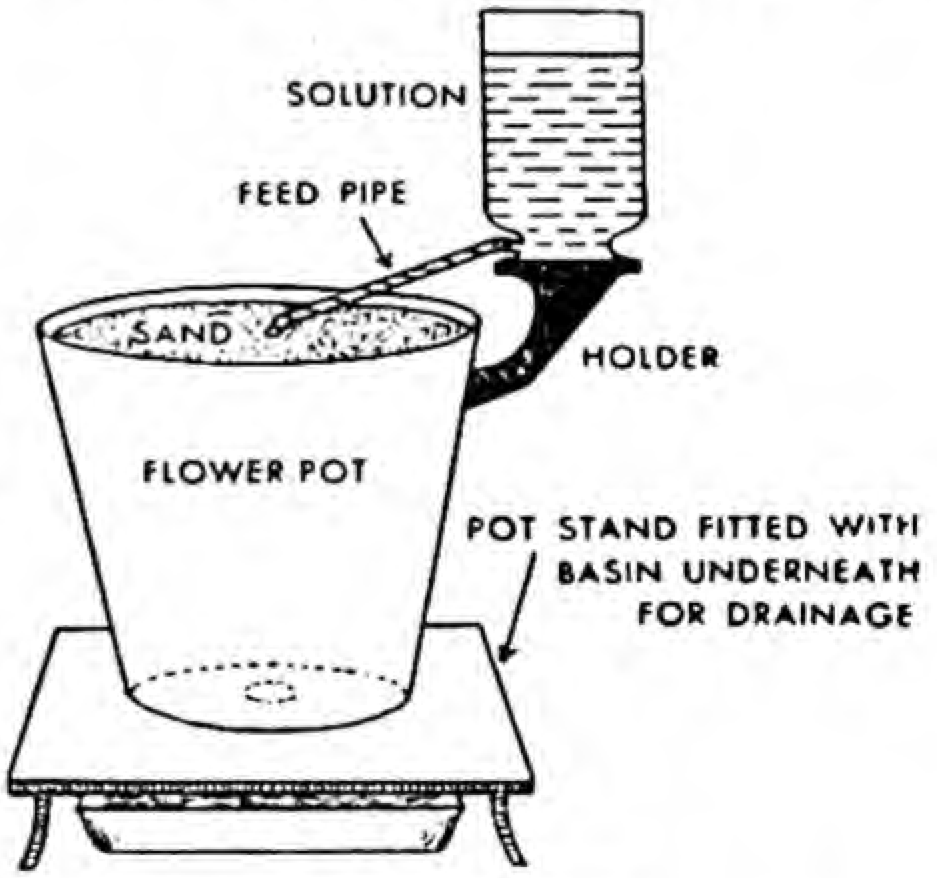


SOLUTION CULTURE

Dr Gericke's original method of soilless cultivation of plants, 1929

impossible. No comparison between the yields of water culture and agriculture had ever been made.

One of the scientists who had given a lot of time to the study of the new technique in his laboratory was Dr W. F. Gericke, a Professor at the University of California. Dr Gericke soon realized the possibilities of the method. Surely, he reasoned, if water culture were to be taken out of the laboratory and turned into a practical and commercial system humanity would benefit greatly. Crop production need no longer be chained to the soil. Barren lands could be made productive, people living in crowded city streets, without gardens, would be able to grow fresh vegetables in window-boxes or on house roofs; and wherever ordinary farming was impossible crops could be raised by methods of soilless cultivation.



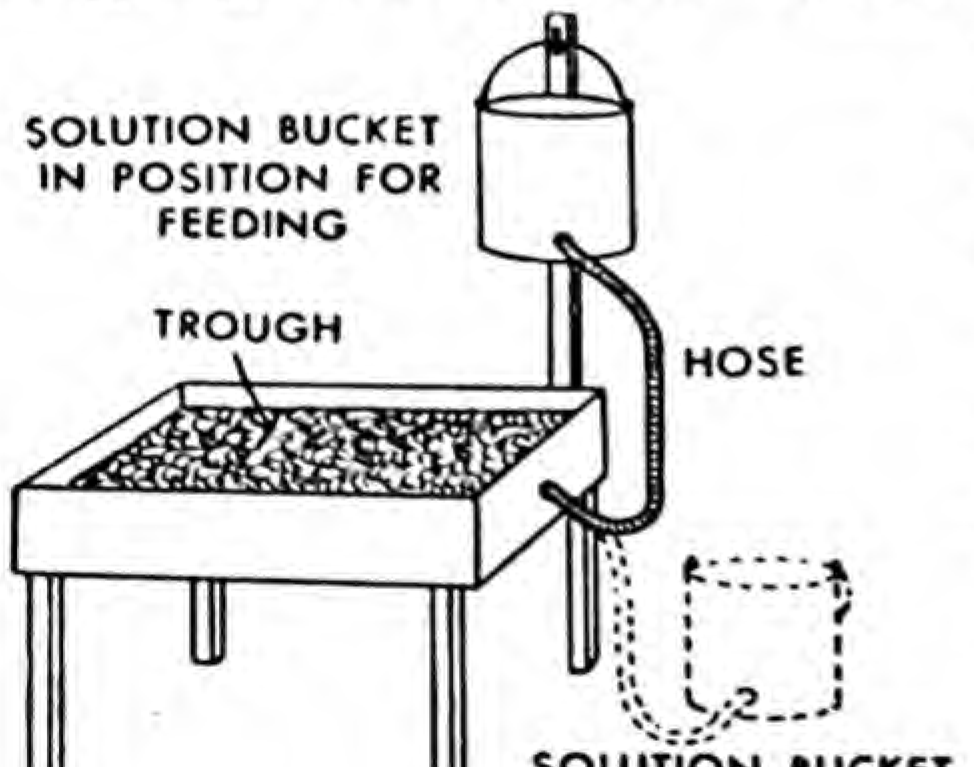
SAND CULTURE

A continuous flow unit for sand culture designed in New Jersey for household use, 1934

With these ideas in mind Dr Gericke set to work and in 1929 startled America by announcing that he had succeeded in growing tomatoes

twenty-five feet in height without any soil! Photographs were seen in the newspapers of the Doctor picking his monster plants with the aid of a step-ladder! But, successful though this first result was, Dr Gericke had to fight a stiff, uphill battle before he could convince the world of the value of his discovery. Jealous rivals received the idea that crops could be grown commercially without soil with scepticism and outright derision. In his book the Doctor tells how the work was done largely in his own time, and with little aid from any scientific organization. His wife's unfaltering faith was a great help to him.

Dr Gericke named the new science 'hydroponics', a word which comes from the Greek language and means 'water-working'. This is just the opposite to 'agriculture' which is Latin for 'care of the earth'.



AGGREGATE CULTURE

A small household aggregate trough

Hydroponics spread rapidly across the United States. Very soon, research institutions throughout America were giving the new science considerable thought and attention. Dr Gericke had grown

his first plants in large basins containing a nutrient solution, but slight changes had to be made to suit different places, so that we find hydroponicists—which is the name for people who grow crops without soil—starting to use sand and gravel kept moist with chemicals and water, instead of just the original liquid.

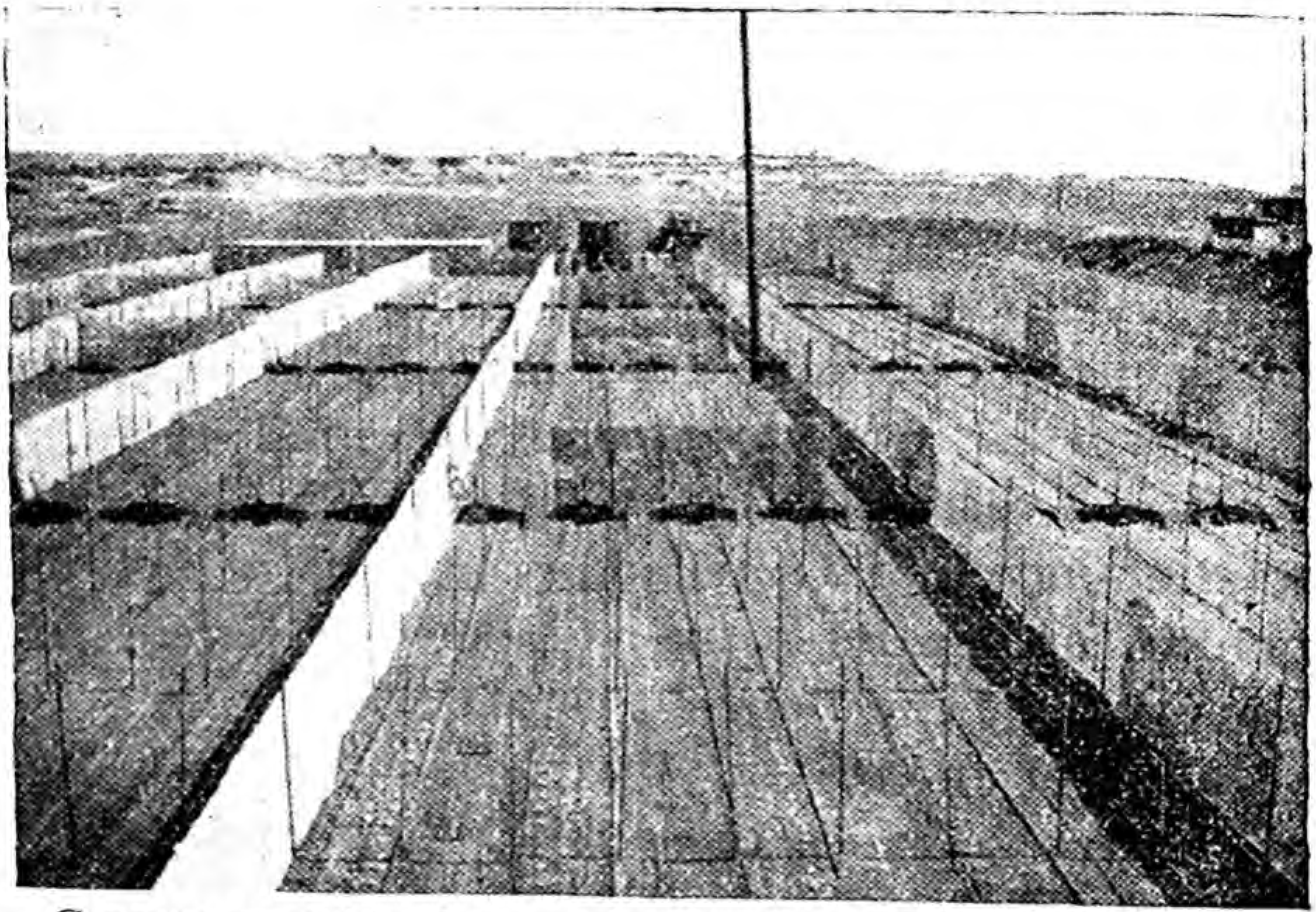
The romance of soilless cultivation now began. Having broken laboratory bounds, hydroponics was soon taken up by business men and commercial organizations. Crop yields far higher than from soil were obtained from hydroponicums—as the troughs or basins in which the plants grow are called. Practical growers praised the new science. But the greatest triumph came when the famous Pan-American Airways decided to establish a hydroponicum on distant Wake Island in the middle of the Pacific Ocean in order to provide the passengers and crews of their air-liners with a regular supply of fresh vegetables. By this time scientists in Europe had become interested. At first they refused to believe the American reports about Dr Gericke's discovery. But after war began in 1939 the British Government began to encourage hydroponics. In 1944 they sent a horticulturalist out to the barren desert of Iraq in order to start soilless cultivation at a large Air Force station there called Habbaniya. This place

was an important link in the communications of the United Nations. Thousands of troops were posted there, and as the area has no fertile soil the problem of supplying these men with fresh vegetables was a difficult one. The only solution that could be found was to bring the vegetables by aeroplane from Palestine, which was an expensive business. But thanks to hydroponics it was soon possible to grow any quantity at Habbaniya itself. In this one case alone soilless cultivation of plants was able to save a lot of time and money.

In England a large industry has been built up around the growing of those beautiful flowers called carnations. Rich Londoners often pay fifteen rupees for a single bloom. Now all these lovely flowers are produced by means of hydroponics, since it has been found quicker and better than soil for carnation growing.

One other instance in which hydroponics has proved of great service is worth mentioning. When the United States Army entered Japan in 1945 they found that there was not only a food shortage, but that little of the local produce was fit to eat. So General MacArthur sent for his hydroponicists and soon a large soilless culture station had been erected, which took over responsibility for the vegetable supply of the American troops.

Nothing is more important to men's health than fresh clean greenstuff, and by ensuring this hydroponics in Japan has saved millions of lives.



Growing vegetables for American troops on the Japanese island of Iwo Jima. (Reproduced by kind permission of the Reinhold Publishing Corporation from the second edition of Ellis and Swaney's *Soilless Growth of Plants*.)

IV

Hydroponics did not reach India until 1946. In the summer of that year one or two far-sighted men, realizing what a boon soilless cultivation of plants would be to the starving millions of this subcontinent, decided to begin experiments. As a result of their efforts the Government of Bengal

gave enough help for a start to be made at Kalimpong near Darjeeling.

Despite opposition, hydroponic work was begun in the autumn of 1946. Many setbacks were experienced. The superstitious primitive local inhabitants denounced it as the work of devils, and several times tried to destroy the plants by throwing big stones into the hydroponicums after dark! Although they succeeded in smashing the experimental plots on many occasions, the patient research workers carefully rebuilt them.

After a year's painstaking effort it was possible to announce that a satisfactory method of hydroponics for use in India had been prepared. It was named 'The Bengal System'.

A lot of interest in the new way of growing plants was shown by the public. Letters began to reach Kalimpong from all over India. In fact people in Pakistan, Burma, Ceylon, Goa and even from islands as far away as Malta and the Seychelles wrote asking for information and help so that they too might start soilless cultivation.

The object in working out the Bengal system of hydroponics was to produce a really simple and practical method so that crops could be grown commercially without much expense. India is a poor country and not many people can afford to buy costly equipment.

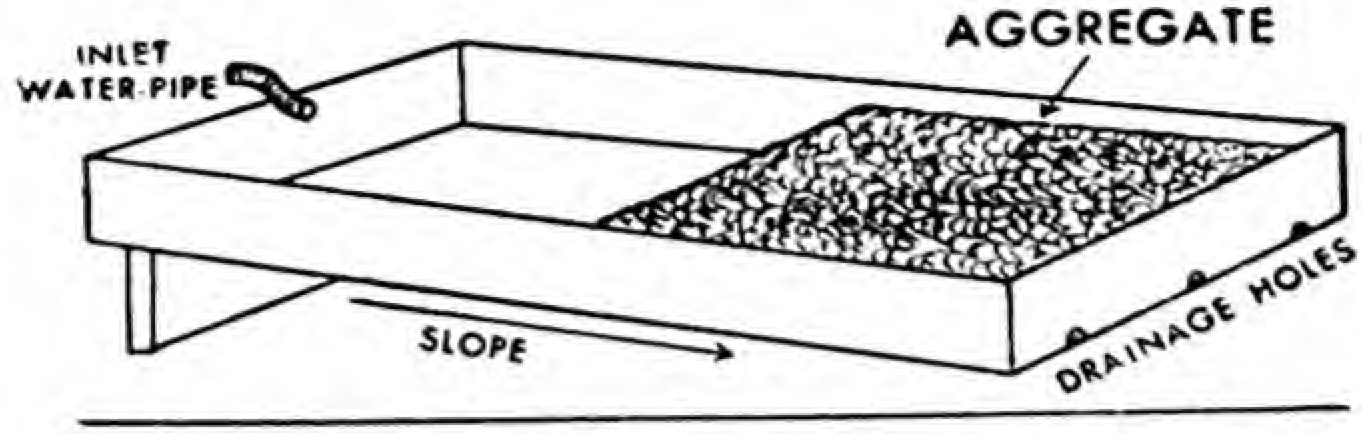
There are three main systems of growing crops without soil. They are called: water or solution culture, sand culture, and aggregate culture. The first thing the research workers at Kalimpong had to do was to choose the best method for India. None of these ways was found to be quite suitable, so the new Bengal System was worked out. This was therefore to a great extent a fresh discovery.

We should not be puzzled over any of the words used to describe things in hydroponics. They are all very simple and quite easy to explain.

In addition to sunshine, air and water, plants require support for their roots. Usually this is provided by the soil, but in hydroponics we use sand; or something called an 'aggregate' like gravel, stone chips or broken bricks. Since soil also contains the elements or mineral salts which plants draw up through their roots as food, when soil is not used we must supply these elements in chemical form just as Sachs and Knop did when they grew the first crops in water culture.

There are ten main elements which plants use for food. They are: nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, boron, zinc, and sulphur. This is quite a long list, but in practice you do not need more than four

or five 'fertilizers'—which is the name for the kind of chemicals or salts which contain these elements.



A HYDROPONIC TROUGH, BENGAL SYSTEM
5 feet wide and 20 feet long

The Kalimpong investigators built several 'troughs' or beds, each five feet wide and twenty feet long. Each trough had a slightly sloping concrete bottom and walls at both sides and ends. The investigators filled the troughs six inches deep with an aggregate consisting of small broken stones and rock dust. Little holes for drainage were made in the wall. The water was allowed to run into the trough from one end until the aggregate was quite moist. The water soaked through the crushed and broken stone aggregate, just as it does through a sponge. As soon as the bed was moist the first tomato seedlings were put in. Each little plant was about five inches high and had been sown in a box full of sand, a month before.

So far the plants had got water and a support for their roots. But if they had been left as they

were in the aggregate trough, we can imagine what would have happened. With no food or elements from which the roots could draw up nourishment the seedlings would have wilted and died.

Consequently a mixture of chemicals or fertilizer salts had to be given. The correct quantities containing the right number of elements were weighed out. After careful mixing, this plant food was scattered on the surface of the aggregate between the rows of seedlings. But if the workers had just left it there, it would not have done much good, since the roots which needed the food were deep under the stones. So water was sprayed on to the trough to drive the chemicals down into the aggregate.

As dry soil is of no value to a plant, so chemical fertilizers are no good unless they become soluble, that is turn into a solution after being mixed with water. This is because the hairs on a plant's roots, which correspond to our mouths, can only absorb food when it is in liquid form.

Thus we can see the reason for washing the dry chemicals down into the aggregate.

All that now remained for the research workers to do was to keep the beds moist. A hosepipe was used to bring water to the troughs on dry days, but sometimes rain fell.

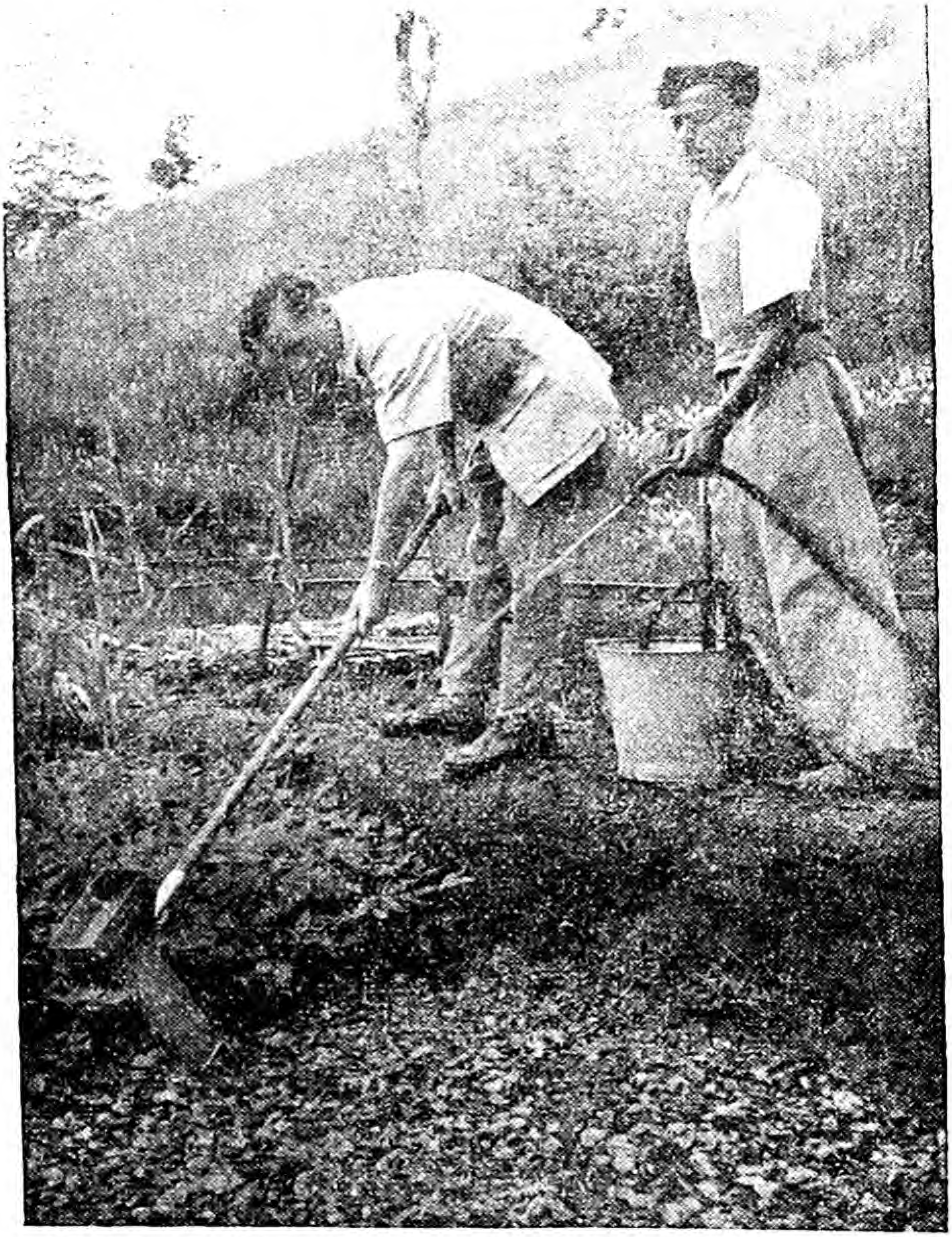
Once a fortnight they sprinkled more chemicals between the plants so that a proper supply of food was always available to the growing crop.

After ninety-one days the first tomatoes were ripe. From a thousand square feet a crop which was valued at over thirteen hundred rupees was picked in the next eleven weeks. To grow this cost only fifteen rupees! The average yield of tomatoes from each plant was 10·6 pounds. Some fruits weighed up to twelve ounces each. This wonderful result was equal to 140 tons to the acre, and far excelled soil yields, which average only 5 to 10 tons to the acre.

V

The quickest way to learn about anything is to try it out for yourself; and after reading all about this wonderful modern discovery called hydroponics this is the first thing that any boy or girl will want to do.

Science is not really a difficult subject, and if you follow the instructions carefully you can easily start a very interesting hydroponic experiment in your own home or at school. Hydroponics is, in fact, a grand hobby for anyone to take up.



Applying nutrient fertilizer to crops

Experiment 1. (For the Hot Weather)

Take a flowerpot, and fill it with a mixture of one part of sand or rock dust and four parts of gravel, crushed stone or broken brick, which should be of a grade not exceeding one-eighth of an inch. Add sufficient water to moisten this aggregate. Care must be taken not to give too much water, and it should not be allowed to stand in the pot. This would kill the plant by taking oxygen away from its roots. Just sufficient water should be given daily to keep the aggregate about as moist as a damp sponge. Plant a maize seed one inch deep in the centre of the pot. After about a week this will have developed into a little seedling.

Mix up the following chemical fertilizer salts, which can be obtained from any good chemist. At school you will be sure to find them in the laboratory. Or if you like you can use one of the other mixtures given for Experiment 2.

MIXTURE A

Nitrate of soda ...	... 5 ounces
Superphosphate ...	... 2½ ounces
Calcium sulphate ...	... 1½ ounces
Potassium sulphate ...	... 2½ ounces
Magnesium sulphate ...	... 2 ounces

Apply this mixture at the rate of one small teaspoonful weekly for the first month, then two small teaspoonfuls each week for the second month, and finally in the third month two and a half small teaspoonfuls at the usual seven days' intervals. When the first lot of fertilizer is finished you can mix up some more, but always take care to store it in a dry tin or box.

Chemicals must never be allowed to fall on the leaves of a plant, since they would 'burn' them. As soon as you have sprinkled the chemical mixture on the surface of the aggregate pour a little water on to the salts to send them into solution and drive them down to the roots of the plant. No fertilizer must be left on the top of the aggregate.

Allow plenty of light and air to your growing plant, and in two months the maize cobs should be ready to eat.

Experiment 2. (For the Cold Weather)

Carry out the preliminary work in the same way as taught in Experiment 1. Here we may mention that if no flowerpots are available any other kind of container may be used, provided a drainage hole is made in the bottom and it is not galvanized iron.

Then carefully plant a tomato seedling about

six inches high in your container after washing the roots clean without breaking any of them.

The same quantities of chemicals and water as for maize must be given, but after the end of the third month do not go over the quantity of two and a half small teaspoonfuls weekly which is laid down. Tomatoes take longer than maize, but you should have fruits ready for eating about two and a half months after transplanting your seedling.

Use one of the fertilizer mixtures given below, and allow plenty of sunshine.

MIXTURE B

Nitrate of soda ...	... 6 ounces
Superphosphate ...	... 3 ounces
Calcium sulphate ...	... 2 ounces
Potassium sulphate ...	... 3 ounces
Magnesium sulphate ...	... 2½ ounces

cr MIXTURE C

Ammonium sulphate ...	... 3½ ounces
Superphosphate ...	... 4 ounces
Potassium sulphate ...	... 2 ounces
Calcium nitrate ...	... 1 ounce
Magnesium sulphate ...	... 3 ounces

or MIXTURE D

Monammonium phosphate	... 1¼ ounces
Potassium nitrate ...	... 6¾ ounces
Calcium nitrate ...	... 1 ounce
Ammonium nitrate ...	... 1 ounce
Magnesium sulphate ...	... 3¾ ounces

or MIXTURE E

Monopotassium phosphate ...	9 ounces
Calcium nitrate	$2\frac{1}{2}$ ounces
Magnesium sulphate	$7\frac{1}{2}$ ounces

Experiment 3. (Large-scale)

If you are keen enough to want to do soilless cultivation on a large scale, then you can lay out troughs as the research workers at Kalimpong did. In that case any one of the chemical mixtures given in Experiments 1 and 2 will be suitable, but you should apply them at the rate of half-an-ounce of fertilizer mixture to each square yard of aggregate surface every ten days, and wash it into solution as instructed.

In addition add 3 drams of zinc and copper sulphate, ten drams of iron sulphate, seven of boric acid powder and nine of manganese chloride to every one hundred and eight pounds of the main mixture.

Experiments like this not only encourage us to do things for ourselves, but also give us a good idea of what a modern scientific achievement like hydroponics means.

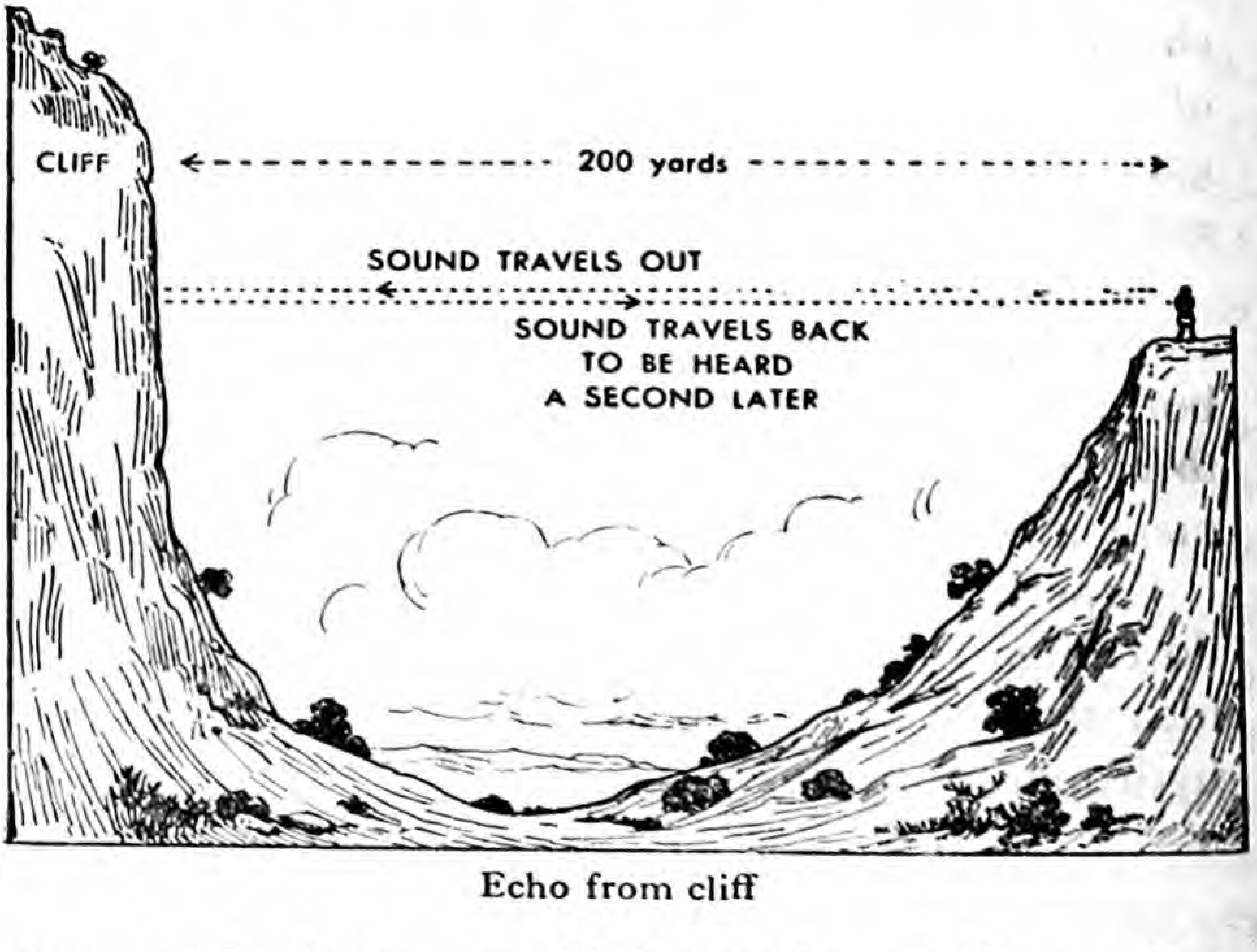
HOW RADAR WORKS

by

PROFESSOR A. M. LOW
Author of 'Science Looks Ahead' and many other popular books on scientific subjects

I

IF YOU STAND some distance from a high wall or a steep, smooth cliff and give a sharp shout, you will hear the sound repeated. The sound waves



Echo from cliff

you made have travelled to the wall or cliff, bounced against it and then returned to be picked

up by your ears. We call this an echo. Radar is a system which uses echoes to find the position and distance of objects. But instead of using sound waves, which are comparatively weak and travel slowly, it uses electro-magnetic waves, the same kind of waves that bring you the talk and music on a wireless receiver, but much shorter and more powerful.

The apparatus used is extremely complicated. If you looked inside a radar set you would find a maze of connecting wires, all sorts of strange radio valves and other devices. In addition there would be complicated aerials, some of them of fantastic shape, in contrast to the simple length of wire which, slung between two poles, is sufficient to pick up the electro-magnetic waves used in broadcasting.

Understanding this very complicated arrangement will be simpler if we go back for a moment to the shout you gave which was echoed by the wall or cliff. If you stood about 200 yards from the cliff and shouted very hard there would be quite an interval before you heard the echoing shout. We can easily work out how long the interval would be. Sound travels at a speed of about 1,100 feet a second. You are 600 feet from the cliff and the sound has to travel there and back, a total of 1,200 feet. It would take about a second to make the journey. If you had a very

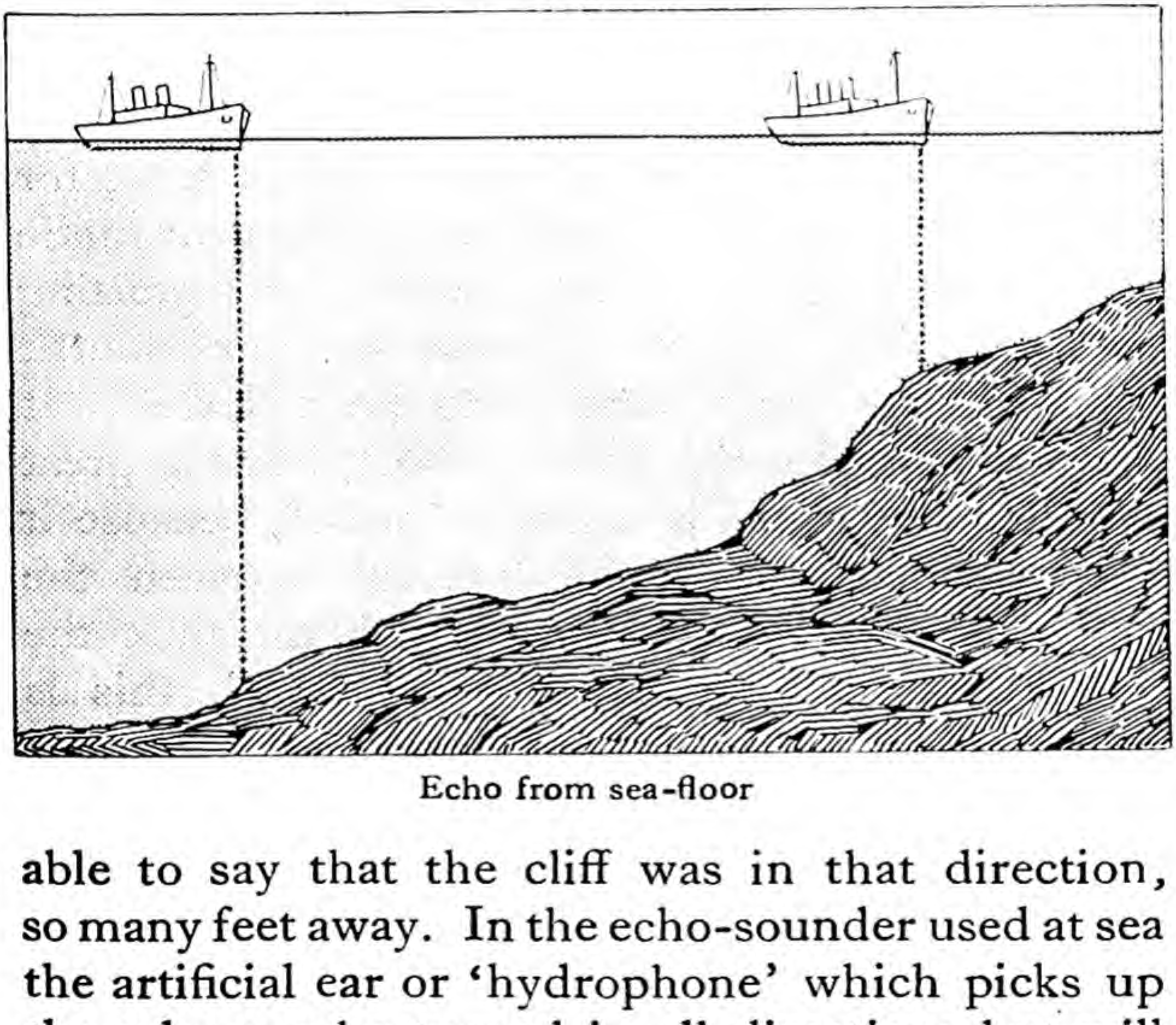
accurate stop-watch you might be able to measure the exact time taken.

This suggests a way of measuring distances without having to put a tape measure over them. You do not know how far away the cliff is. So you shout and measure the time that elapses before you hear the echo. When you know this you can easily work out how far the sound has travelled and half this will be the distance away of the cliff.

This is quite a practical way of measuring distances in certain conditions. As a matter of fact we know now that it is roughly the way that a bat, flying in the dark, measures its distance from obstacles such as telephone wires. The bat emits very high-pitched sounds, too high for the human ear to hear. These bounce back from any obstruction near and the bat is warned in time to swerve away. 'Echo-sounding' is used at sea. A sound is sent out from the bottom of a ship, bounces against the bottom of the sea and returns to the ship. The time it takes to make this journey is measured and it is then easy to calculate how far under the ship's keel is the bottom of the sea. This is a very valuable device which is much less clumsy for sounding than a piece of lead on the end of a rope.

Timing an echo will tell you how far away is

the surface reflecting the sound. But it will not tell you in what direction it is. Because you have two ears, you can tell, roughly, from what direction a sound is coming. If you were blindfolded and turned slowly round shouting, you would get an echo only from one point and you would be



Echo from sea-floor

able to say that the cliff was in that direction, so many feet away. In the echo-sounder used at sea the artificial ear or 'hydrophone' which picks up the echo can be turned in all directions but will only pick up the echo in one direction. Moreover, if the depth is measured at frequent intervals, while the ship is moving slowly, you get a 'picture'

of the bottom of the sea. Normally this would be level, but if there was a wreck below, it would be shown as a sharp hump.

II

Sound can be used for finding distances and directions only to a very limited degree. Sound waves are comparatively feeble and if the reflecting surface were, say, a mile away, the echo would be too slight to be picked up. That is why, for radar, instead of sound we use electro-magnetic waves which have great energy. The transmitting part of a radar set corresponds to your mouth: it makes the signal that is to be reflected. It produces a signal that is very short, but has great energy. The signal is called a 'pulse', because it beats regularly, and the interval between the pulses is very long compared with the time the pulse lasts. When we say 'very long', this is comparative, for the interval between pulses is only a few thousandths of a second, a time so short that it is difficult to imagine it. But it is a long time compared to that during which a pulse is sent; that may be only a millionth of a second or even less.

Because electro-magnetic waves travel so fast, this few-thousandths-of-a-second interval is quite long enough for the pulse to reach the echoing

surface several miles away and to return. The pulse travels with the speed of light—186,000 *miles* a second. Before the second pulse is sent out, the first has travelled to an aeroplane or ship far away, been reflected, and travelled back to the radar installation. If there was not this interval successive pulses would get mixed up and the receiver would not be able to tell whether the echo it was receiving was that of the first, second or third pulse.

The receiving part of the set corresponds to your ears. It picks up the reflected pulses. You will see, therefore, that a radar installation is different from a 'wireless station' because both the transmitter and the receiver are situated at the same place. To tell the direction from which the pulse is reflected, the receiver works with an aerial that can be moved round, just as your head moves round on your neck. From certain positions the receiver will get no echo, from others it gets an echo and records that there is something there.

The receiver measures the very short time that the pulse takes to make its journey and from this can be calculated the distance of the reflecting object. One of the wonders of radar is the way these very short times taken for the pulse to make its journey are measured. If the aeroplane or

ship is only 1,000 yards away from the transmitter so that the pulse has to travel 2,000 yards on its double journey, the receiver must measure a time of only six millionths of a second. It does it easily. In fact, we have radar instruments which can measure a period of time as small as one-thirtieth of a millionth of a second, a vastly shorter time than it takes you to blink your eyes.

No watch could record these very short intervals of time: a man needs about a tenth of a second merely for the message to press a stop-watch to pass from his eyes to his brain and then to his hand-muscles. The time is measured electrically. And it would be no help at all for the figure to be presented to a man for calculation. By the time he had worked out just what distance the millionth of a second meant, the aeroplane would be a long way away and more pulses would be bringing new signals.

The result of the signals received therefore is shown visually, 'displayed' as radar technicians call it. The signals are made to operate on an instrument known as a cathode ray tube in which electrons, moving in terms of millionths of a second, bombard a special screen. Their impact produces fluorescence, and the echoes succeeding each other at intervals of a few thousandths of a second produce a spot of light or 'pip'. This is shown

on a scale and the operator can immediately see that the reflecting object is 1,000, 1,050, 1,100 or whatever it may be, yards away. As the object moves nearer or further, so the change is indicated by the pip moving on the 'display'.

This is only one way of 'displaying' the echoed signals. The most spectacular way is a method called the Plan Position Indicator. In this a revolving aerial brings in echoes from all directions. They are correctly sorted out by the receiver and then displayed on a screen the centre of which is the position of the operator. One of these operating in an aeroplane would show a 'plan' of the ground underneath, even in pitch darkness and through thick fog, for these electro-magnetic signals are not, like light, cut off by fog. On a ship the Plan Position Indicator would show everything on the water right round the ship. It would show, perhaps, another ship a thousand yards off in one direction, several others at different distances in other directions, and perhaps on one side the shore line. Even a buoy lying on the water would be indicated. Everything would be in its right place and direction. But it is not a 'photograph' or 'picture' as on a television screen. As the name suggests, it is a 'plan': the ships would be indicated by lines of light, the shore by another line. To the uninitiated it might not mean very

much, but to the trained operator with a map imposed on the screen or beside it, the plan would be a real picture.

III

That in principle is how a radar installation works, but there are many details that are extremely interesting. When you shout, the sound goes out at a wide angle. It would be heard by people standing all round you, although it would be much louder to those standing directly in front of you. For real direction-finding, you need a direction signal. That is to say a signal that goes out in a narrow beam instead of over a widely dispersed area. If you could shout in a narrow channel only a yard wide, the sound would be echoed by a wall only a yard wide when you exactly faced it and not echoed at all when you moved to either side. The narrower the beam, the smaller the object you could detect. With a beam a yard wide, you would get an echo from an object only six inches wide, but you would get it from many positions of the beam. With a beam only six inches wide, you would get it only from one position of the beam.

The 'sharpness' of a radar set depends upon the sharpness of the beam of pulses sent out. The narrower and more knife-like the beam, the more accurate the picture painted on the display. It is

the exact opposite to what is required in broadcasting sound, where you want the signals to be sent in every direction. Now it is a fact of radio that with an aerial of a certain size, the shorter the wavelength of the signals, the sharper the beam can be made. It is for this reason that radar uses 'micro-waves' instead of the comparatively long waves used for broadcasting. Instead of waves of anything from a few yards to over a mile in length as used in wireless transmission, radar uses waves a fraction of an inch in length. This enables the signals to be sent in a narrow beam like that of a searchlight, and the resulting accuracy makes it possible to say, in pitch darkness, whether a ship is, say, 6,000 yards away or 6,010 yards away.

The short waves used for radar have the disadvantage that their range is limited by the curvature of the earth—they cannot travel much further than you could see in perfect conditions of light. This does not matter so much in the air—you can see an aeroplane hundreds of miles away provided it is sufficiently high—but it limits the range of radar at sea.

IV

There are many different kinds of radar installations for different purposes, but they all have five essential parts. There is the modulator

which produces the energy in electro-magnetic form. We might say it corresponded to your lungs sending up the air which makes your vocal chords vibrate. Then there is the radio-frequency oscillator. This is really a wireless valve of a special type which produces the bursts of energy we call pulses at the right intervals; it corresponds roughly to your vocal chords, tongue and lips giving form to the sound as you say *Ah . . . ah . . . ah . . .*, each *ah* being a pulse.

Then there is the aerial which is very directional, used both for sending out and receiving the pulses. Some of the aerials are extremely ingenious. For instance, an aerial on a ship would have to be arranged so that the rolling or pitching of the ship did not affect its position in space.

Fourth, there is the receiver, which has to be of a special type, quite different from that used for receiving broadcasting. One of the special difficulties is that the receiver has to be disconnected with the aerial every time a pulse is sent out—in other words many times a second. If it were not disconnected, the receiver would be burned out by the tremendous burst of energy in the transmitting pulse: the echoed pulse is, of course, much more feeble. This disconnexion is done electrically. No mechanical device could do it with sufficient speed.

Last we have the display, the part of the radar set that attracts attention. The signals received are amplified and then made to show themselves in a way that can be understood. It may be by a 'pip', a V-shaped break in a luminous line across the screen, or it may be a Plan Position Indicator where, by the ingenious use of a material which continues to glow for a fraction of a second after the signal has passed, the whole surroundings are displayed at once. If it were not for this luminous material which continues to glow, the revolving aerial would show surrounding objects simply as a series of rapid flashes as it picked them up one after another.

V

Radar was developed during the war and the applications until 1945 were, naturally, all concerned with aircraft, guns and battleships. It was used in various ways. Radar detected approaching aeroplanes long before they could be seen and gave their exact numbers, distance and height. Radar installations could pick up aircraft assembling for a raid hundreds of miles away. It was used to guide bombers to their target. Radar could calculate the distance of the target much more accurately than any human being, and bombs were actually released by radar operators hundreds of

miles away, the crew of the aircraft simply taking it on the indicated line. Because radar could penetrate darkness and cloud it was used for picking out targets from aeroplanes. Radar was coupled to searchlights and anti-aircraft guns: the aerials automatically kept track of the aircraft and the signals, instead of being 'displayed', were made to work the movement of the guns. At sea, radar was used for 'spotting' submarines and raiding craft in darkness and for ranging the guns of big battleships, which were thus able to fire with great accuracy at targets they could not see.

Minute radar sets were built to fit into the nose of shells. The shells were fired in the general direction of an aeroplane. The radar set started transmitting. When the pulses struck the aeroplane, were reflected back to the receiver in the set and indicated the aeroplane was near, the shell exploded. Instead of the received signals being 'displayed', they ignited the fuse of the shell.

In peacetime, radar is coming to have extremely important uses. It enables commercial aircraft to be guided to aerodromes in conditions of poor visibility and at night. This method of landing is called 'talking down'. The controller on the ground has a radar installation which shows him the exact position of the approaching aeroplane.

He has a transmitter for speaking to the aeroplane, tells it where it is, what height to fly and in what direction, and thus brings it safely down to a few feet above the aerodrome when the pilot can see sufficiently to land.

It would be possible to have radar sets in all planes to prevent collisions with each other or with mountains. But radar installations are not only very expensive but also very bulky, and it is at present more simple to have safety rules for eliminating the risk of collisions.

At sea, the great value of radar is for preventing collisions in fog. With a Plan Position Indicator the captain on his bridge can see everything round him even in thick fog and thread his way through a narrow channel which is also being used by other ships. In the open sea he can detect obstacles such as an iceberg; you will remember that an iceberg sank the *Titanic* in one of the worst sea disasters of all time.

The value of a radar installation for steering in fog is limited until every ship can be equipped. The captain with his radar can see other ships, but unless he can be sure they can see him, he will not feel certain that there may not be a collision. For this reason radar is being used in a different way in busy ports such as Liverpool and Southampton where delays due to fog can be

considerable. The radar installation is on land and picks up the ships, and the operator gives the ships orders how to steer. The operator can see all the ships and thus keep them clear of each other. This resembles 'talking down' on an aerodrome.

A very interesting development of radar is likely to be installations which will enable the blind to 'see'. By turning the echoed impulses into sound, a blind man walking along the street could be warned of anyone approaching, of a wall or a motor car. There are great difficulties. Radar does not work well at distances of less than a few hundred yards because there is no time for the echo to be picked up; if you stand too close to a wall you do not hear the echo because it almost coincides with your own shout. The radar set would have to be very easily portable. But it is believed these difficulties may be overcome in time and that radar, although it does not restore sight to the blind, will at least remove many of their handicaps in travelling without other human aid.

YOUTH BUILDS A RAILWAY

by

ROMESH THAPAR

Editor of a weekly newspaper, who visited Yugoslavia in 1947

I

MANY THOUSANDS of miles from India and a night's journey from the blue waters of the Adriatic Sea there is situated in a barren, desolate village surrounded by rocky hills and within walking distance of Sarajevo a small tumbledown village. The name is not important, for there are many such villages in Yugoslavia. It was here that Danica (pronounced Daaneetsa) lived.

When the armies of Nazi Germany invaded her country in 1941, Danica was a slender girl of fifteen. Ten of the fifteen years of her life had been spent in the United States of America where her father had migrated in search of regular work. He was a coal-miner by profession and his dangerous life suddenly ended when he was killed in a pit explosion.

Danica's mother decided to use the money that they received from the Mining Company as compensation in order to return to the land of their ancestors. And so, in 1935, Danica and her

mother came back to Yugoslavia, to the village from which her parents had set out to build a new life in a country which they had heard was rich and prosperous.

After their return to Yugoslavia five years had passed, years of intense poverty and suffering. Danica was too young to work and her mother found it difficult to earn enough tc buy food. Friends and relatives, however, had helped them to keep alive.

There was no school in the village. Danica had been a studious girl but she soon forgot the little that she had learnt. Life was very dull and very cruel.

The sleepy and isolated life of the village was abruptly changed when the invading Germans entered Sarajevo. That night, Danica and her mother were awakened by the sound of rifle fire and it came from the far end of their village. Even as they were wondering what to do, a neighbour rushed in to warn them that a company of German soldiers had entered the village and that the officer in charge was demanding food and accommodation; those who had resisted had been shot. Danica did not sleep that night. A new fear had come into her life.

Several months passed. Many people from the village and friends in Sarajevo were rounded up

and taken away to some unknown destination. Danica and her mother, like most of the inhabitants of the village, kept away from the German soldiers, for that was the best way of avoiding trouble. Sometimes there was an incident, but nothing very serious. Anyone who mixed with the invaders was boycotted and could never expcct help from his fellow countrymen.

Winter had come. There was snow all around. The stream that ran past the village was frozen. There was little to eat. Early one bitterly cold morning, Danica's mother announced that she would have to work for the Germans. Danica, who had become a fiery nationalist, was so shocked that she just stared at her mother and said nothing.

Danica's mother worked for many months with the Germans. The rest of the village despised both mother and daughter. The feeling against them was very intense, for in the mountains armed Yugoslavs were beginning to resist the invader. Danica's mother was well paid by the German soldiers; she could talk their language and was a good cook.

One afternoon, when Danica was sewing her old dress, one of the elders of the village entered their hut and put his arm around her affectionately. He then told Danica that her mother

had been arrested by the Germans for being a spy of the partisans who were fighting in the mountains. He told Danica to pack her few belongings and flee from the village, for the Germans were certain to arrest her also. The old man gave her an address in Sarajevo and told her to contact his friend who would look after her.

Danica lost no time in leaving the village. She made for Sarajevo, careful to avoid the main road. She reached her destination and was warmly welcomed by a young man of about twenty-six who was the local leader of the Peoples Youth, an organization which had mobilized the young people to fight the German invaders.

From him Danica learnt that the struggle for freedom was spreading rapidly and that the young people of Yugoslavia were playing a very prominent part in it. He told her of many thrilling actions in which he himself had taken part, of the great courage and heroism of young people like herself.

Josip was the name of the young man who now started to train Danica to play her part in the liberation of her country. Working with him, carrying his messages to mountain outposts, doing small and dangerous jobs, Danica began to feel that life was worth living. Danica moved around in a *burqa*. This was an excellent disguise, for

Sarajevo is in a sense a Muslim city and is the headquarters of the two million followers of Islam who live in Yugoslavia.

II

After the Germans had been defeated and Yugoslavia had been liberated, the Peoples Youth was reorganized and expanded. And Danica became one of the leaders of this organization. She was the proud possessor of two war decorations, and when she visited her home the whole village turned out to welcome her. Her mother had been killed. Almost every family in this region had lost a dear one. Danica did not weep. The war had taught her many things. She was going to return to the Peoples Youth and help build a new Yugoslavia in which there would be no poverty and misery.

At the time of liberation, Yugoslavia was a devastated land. Thousands of villages had changed hands many times; all that remained of them now was rubble. Roads, bridges, railway tracks had been destroyed. There was a big shortage of transport vehicles and railway wagons. Indeed, no country could have been in a worse condition. To add to the troubles of the people, there was a grave shortage of food, and in the south whole areas were famine-stricken.

It was at this time that Marshal Tito, the leader of the Yugoslav liberation movement and head of the newly-founded Republic, called upon the Peoples Youth to take their positions in the forefront of the reconstruction drive. He told them that they were the rulers of tomorrow, that they were the best fitted to build the new Yugoslavia. Everything was done to make the youth of Yugoslavia feel that the future of their country lay in their hands. Youth leaders like Danica and Josip, who were rèspected and honoured for their work during the liberation movement, organized propaganda tours to far-off villages and took the message of Marshal Tito to the people.

Danica decided to concentrate on the villages in the Sarajevo region. She knew the people of this area and could speak their language. She was also better known in the south among the young people. It was a difficult task she had set herself. The devastation was so great that everyone was more concerned with rebuilding at home than with giant reconstruction projects. But undaunted, she began her tour.

Often she had to walk miles and miles with her friends, for roads and railways were few, and even where they did exist there were no means of transport; in the old days, the horse-driven cart was the usual means of conveyance but now the

carts were useless because the Germans had killed most of the horses.

Danica and her fellow workers soon found that it was not easy to convince parents to give their children permission to join the Youth Brigades. Mothers were reluctant to let their daughters go for fear that they might fall into bad company. Fathers felt that their sons should remain to help rebuild the farms. But the independent-minded among the youth responded immediately to the call of service. Danica was at first disappointed that the numbers who came forward were not as large as she had hoped. Later, she consoled herself with the thought that great things always begin in a small way.

III

Youth work brigades began to assemble all over Yugoslavia at the beginning of 1946. They had offered to give three months' free service to the nation. Work began. Almost every district of the country undertook one or more projects, selected in such a way that they could be completed in three months.

A vast organization had to be built up from scratch. Youth workers had to be housed, clothed and fed. Marshal Tito had also insisted that spare time should not be wasted. Education and

cultural classes had to be organized. Outdoor games, cinema shows and dramatics were an important part of the programme. All these schemes were planned and directed by the more experienced youth leaders like Danica under the guidance of trained experts.

Work on the projects began with tremendous enthusiasm. Acting on plans prepared jointly by experienced technicians and youth leaders, the youth brigades built hundreds of miles of new canals, roads and embankments. Swamp lands were drained. Thousands of acres of land were reclaimed. Water was brought by means of canals to parched lands which had never before yielded a crop. New highways were built to connect important towns. Even the mighty Danube had to give way; the Ramski canal and embankment deprived it of two thousand hectares of land.

Danica saw this mighty wave of working enthusiasm sweep the country, but what really gladdened her heart was the sight of hundreds of new recruits arriving at the projects from neighbouring villages. Muslim girls, carrying their *burqas*, also came forward determined to play their part in the building of a new Yugoslavia.

The youth of Yugoslavia had suddenly realized its own strength. Here was a method of combining

a grand holiday with thrilling collective work which would give them sufficient experience to get jobs or even to start their own business. The

rush from the villages was so great that, in many areas, food and accommodation arrangements broke down. Hundreds had to be sent back to their homes.

The stage was now set for the most remarkable venture of all—the building of the world's first Youth Railway. The project was launched by the Peoples Youth of Yugoslavia, a voluntary organization which had now reached a membership of two million.

For the first time in world history, youth was going to build a railway. More important was the

fact that the railway itself would be of vital help to Yugoslavia's reconstruction. The first stretch of railway to be built was from Brcko to Banovici, a distance of fifty-five miles which would require the construction of two hundred bridges. Once

Photograph, Henry Grant

Tightening bolts on the railway. This part of the line, near Samac, runs through flat country.

constructed, the railway would make possible the exploitation of the rich coal mines in the Banovici area and also act as another artery for the distribution of supplies to an area which had always suffered from shortages.

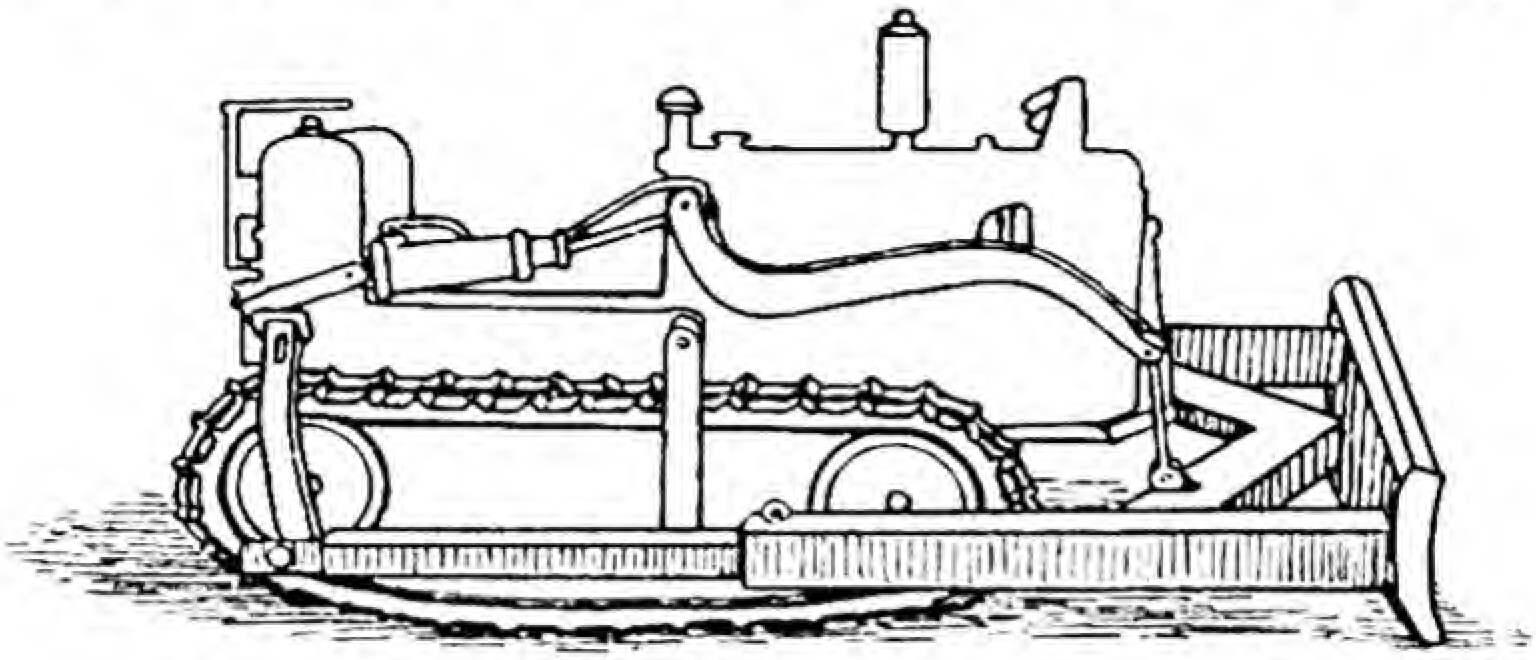
So great were the difficulties in building the railway that the Yugoslav planning authorities had postponed the scheme for want of money and manpower. The Peoples Youth decided that work should be undertaken by their organization at once. Sixty-two thousand members of the Peoples Youth were mobilized to begin the work of construction.

On 9 April 1946, the final decision was taken that the Peoples Youth should build the railway. Even then the experts and veteran technicians were full of doubts that youth, no matter how enthusiastic, could build a railway. But Danica and her friends went ahead full of confidence. An S O S went out to the youth of Yugoslavia to organize voluntary brigades to work in three two-monthly shifts throughout the summer: from May to July, from July to September, and from September to November. On 1 May, the first shift of 14,500 was ready to start.

UNRRA, the United Nations Relief and Rehabilitation Administration, immediately came to the help of the Peoples Youth and provided badly-needed equipment. With 140 trucks, 17 powerful bulldozers, a giant stone-breaker, concrete-mixers, electric generators and other appliances, the first 14,500 began the unique experiment.

Skilled experts were scarce, so the best of the

young workers concentrated on learning skilled jobs: sixty-two of them learnt to drive bulldozers, 440 became tunnelers, 230 skilled track-layers,



A bulldozer. The strong belts over the wheels enable it to move over rough or slippery ground, and the bar in front can be raised or lowered to push away soil, stones or trees.

1,500 masons and bricklayers, 275 surveyors, 768 assistant overseers, 69 mechanics and drivers, and 63 telephonists and telegraphists. For the vast majority of volunteers the main task was heavy manual work, and the line progressed as the result of much toil and sweat.

The working day was six hours, though voluntary overtime was done on urgent jobs. Life was organized in brigades of approximately 250 members each, with their own feeding and housing arrangements. Each brigade had its own First Aid Post and each Section had a small hospital. Competitions between brigades for good results, both at work and sport, were a regular feature

of life along the line. Singing, dancing, study groups, discussions and sport all occupied the volunteers' free time. Special awards were given to those who distinguished themselves, and the most coveted award was the Udarnik or Shock Worker Medal.

IV

As the story of this remarkable youth project spread to other countries of the world, students from abroad visited Yugoslavia to work on the Youth Railway. To many, their trip to Yugoslavia became the most thrilling experience of their lives. For the first time they had seen people like themselves building a new world. They saw the youth of Yugoslavia engaged in a grim fight with Nature, but inspired by a vigorous faith in their strength and victory.

The Youth Railway was a miraculous success, defying all the gloomy forecasts of old experts who said that it could never be accomplished. It was accomplished—three weeks ahead of schedule, on 7 November 1946. Brcko and Banovici had been linked. The Youth of Yugoslavia had triumphed.

Now nothing could stop the Youth of Yugoslavia. They offered to undertake an even more difficult task—the building of the railway between Samac and Sarajevo in the summer of 1947, a distance of 150 miles with 37 stations, five

bridges (one of them 800 yards long) and four tunnels, one a mile in length. The leadership of the Peoples Youth offered to mobilize 180,000 people to work on the project. This courageous offer was warmly accepted by the Yugoslav Government and the planning work began without delay.

Photograph, Henry Grant

After the day's work on the railway was finished, open-air classes like this were held. The more advanced students taught the rest.

The work was launched on 1 April 1947 and was completed ahead of schedule and before 29 November, the day which marks the anniversary of the founding of the Republic of Yugoslavia.

This Youth Railway passed through mountainous country through the valley of the Bosnia River and has made possible the exploitation of large coal and iron resources and the development of the forest wealth of this region. It still represents the greatest single achievement of the Peoples Youth.

While the railway was being built, foreign brigades were invited, and they came from thirty nations including Albania, Greece, Hungary, Bulgaria, Denmark, Sweden, Rumania, Poland, Czechoslovakia, Switzerland, France, Palestine, Australia, Norway, Holland, Canada and England. Small groups from other countries also visited Yugoslavia, including students from India. One of the Indians, a Parsee from Bombay, was awarded the Udarnik Medal for his distinguished work on the Samac-Sarajevo railway. Over five thousand foreign students joined with the Yugoslavs to help build the greatest Youth Railway of all time. This indeed was a fine symbol of international co-operation.

I was in Sarajevo when Marshal Tito inaugurated the Youth Railway of Samac–Sarajevo. Twenty-eight thousand young men and women marched past the leader of the Yugoslav people. The whole of Sarajevo was in festive mood. There was dancing and singing in the

streets. The Peoples Youth were the heroes of the day.

That evening I sat in a cafe watching the merry crowds, and my companion was none other than Danica herself. She had played a prominent part in the activities of the Peoples Youth. Few would have recognized the new Danica. She was full of courage and faith, very different from the girl who had fled from her village after the Germans had murdered her mother.

We had been talking for over two hours. She had told me her story and the story of the Peoples Youth. For a few minutes we listened in silence to one of the popular songs of the Peoples Youth. Then Danica turned to me and said, 'I shall be visiting my village tomorrow, after almost a year. You must come with me and see how we peasants live.'

The next day we visited Danica's village. It had been entirely reconstructed and was being run on co-operative lines. Seeing the surprise on my face, she smiled and said, 'The members of the Peoples Youth who stayed behind organized the building of the village. It was just a rubble heap after the Germans had finished.'

It was evening, and as we prepared to return to Sarajevo, Danica began to walk towards the graveyard. I went with her. She took me to her

mother's grave. She knelt down and said a small prayer. Getting up, she turned to me and said, 'I'm glad you could come and see the Peoples Youth in action. My only wish is that my mother had been alive today to see the new Yugoslavia. I hope you will tell the young people of India what we are doing. One day, I am sure, they also will have their Peoples Youth and build many many railways.'

Coming back to Sarajevo and seeing the tall, slender minarets of this very oriental city silhouetted against the darkening sky, I knew that the youth of Yugoslavia had taught the world a great lesson in comradeship and devotion to work, a lesson that we in India would one day certainly emulate.

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QUESTIONS AND EXERCISES

NATURE'S WONDERFUL FREE GIFT

1. Find a picture of a spaniel dog and pictures of four other kinds of dog.

2. Name four examples of sun-cure that Rollier noticed.

3. Write 50 words about the Red Indians—where they live, how they are dressed, and why they were Rollier's childhood heroes.

4. Translate into your own language:

   Not more than a dozen years were left before the dawn of the twentieth century.

   They bathed their meat in the sun and thus preserved it against vermin.

   He used no machines, he discarded his medicine bottles.

THE IMPORTANCE OF WATER IN INDIA AND PAKISTAN

1. Mark the Damodar, Kosi, Narbada, Tapti, Chambal and Tungabhadra rivers on a sketch map.

2. Why is it necessary to store large quantities of water in India and Pakistan?

3. In what parts of India and Pakistan are there good underground stores of water?

4. Describe a dam or a canal or a hydro-electric station you have seen.

5. Describe how the flooding of rivers can be checked.

6. Translate into your own language:

   I constrained the mighty river to flow according to my will.

It is very seldom that the rainfall in any particular year is the same as the average.

This problem of soil erosion is receiving the attention of the Damodar Valley Corporation.

BIRD-WATCHING

1. Make a sketch of Salim Ali watching the weaver birds on his 'cross between a high stool and a step-ladder'.
2. Explain what the author means by 'control colony'.
3. What did the author learn from his observations?
4. Translate:

   There seemed to be none of that connubial co-operation in the building of the nest previously described by one writer after another.

   Not infrequently, due to some defect in the construction which fails to please the capricious female eye, a nest goes unaccepted by one visiting female after another.

EXPLORING THE ATOM

1. The author says specks of dust are perhaps the smallest particles of matter 'visible to the naked eye'. How do scientists see things not visible to the naked eye?
2. What is the present theory of the structure of the atom?
3. 'The world's energy comes, for the most part, from coal and oil.' Describe another great source of energy.
4. Use in new sentences the words:

   Bombardment, discharge, evacuated, pulse.

CLIMBING

1. How does a map-maker use a theodolite? Find a picture of a theodolite if you can.

2. Describe the expedition from Mussoorie.

3. Lassi is made from milk. Name as many other milk-products as you can and describe how they are made.

4. Collect ten different flowers, and name them.

CROPS WITHOUT SOIL

1. Provide titles for the five parts of this chapter.

2. List some differences between agriculture and water culture.

3. What discovery did Sir Humphrey Davy make which helped scientists to know the elements in a compound?

4. Translate into your own language:

   Crop production need no longer be chained to the soil.

   After a year's painstaking effort it was possible to announce that a satisfactory method of hydroponics for use in India had been prepared.

HOW RADAR WORKS

1. Draw a maze. (The author says: 'If you looked inside a radar set you would find a maze of connecting wires', but by 'maze' he only means a lot of wires crossing in all directions.)

2. What is the difference between radio waves and radar waves?

3. Name the five essential parts of a radar installation.

4. Translate into your own language:

   Radar was coupled to searchlights and anti-aircraft guns.

Radar was used for 'spotting' submarines.

Radar was used for ranging the guns of big battleships.

YOUTH BUILDS A RAILWAY

1. Imagine you are one of the workers on the Samac-Sarajevo railway and describe a day in your life.

2. What did the skilled workers do to help to make the railway? What did the others do?

3. Use in new sentences:

round up, shock worker, S O S, outpost.

4. Are any more railways needed in India and Pakistan? If so, suggest some new lines.

GENERAL QUESTIONS

1. Which chapter did you like best?

2. Which chapter did you find most difficult to understand?

3. Have you tried any of the experiments (with echoes, with birds, with plants)?

4. Are you making searches and discoveries every day? Name three of your latest discoveries.

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OXFORD JUNIOR ENCYCLOPAEDIA

General Editors:

LAURA E. SALT *and* GEOFFREY BOUMPHREY

Illustrations Editor: HELEN MARY PETTER

Volume II: NATURAL HISTORY

Advisory Editor: M. BURTON
Assistant Keeper at the British Museum (Natural History)

Crown 4to, pp. 512, 600 illustrations, 8 colour plates, 30s.

The subject of this volume of the *Oxford Junior Encyclopaedia* is Natural History—the plants and animals living on the earth. It gives accounts of all the main groups—flowering plants, conifers, fungi, and mammals, birds, fish, insects, etc., and describes how they grow, reproduce, feed and move. The functions of the different parts of plants and flowers and of an animal's body are described.

The main concern of the volume, however, is with way of life and behaviour. Plants with special devices for living, such as climbing plants or insectivorous plants, and those adapted for special types of environment, are all described. Separate accounts of the better-known animals are included.

The Encyclopaedia will be completed in twelve separate volumes each dealing with one subject-group. The volumes already published are: I, *Mankind*; II, *Natural History*; III, *The Universe*.

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